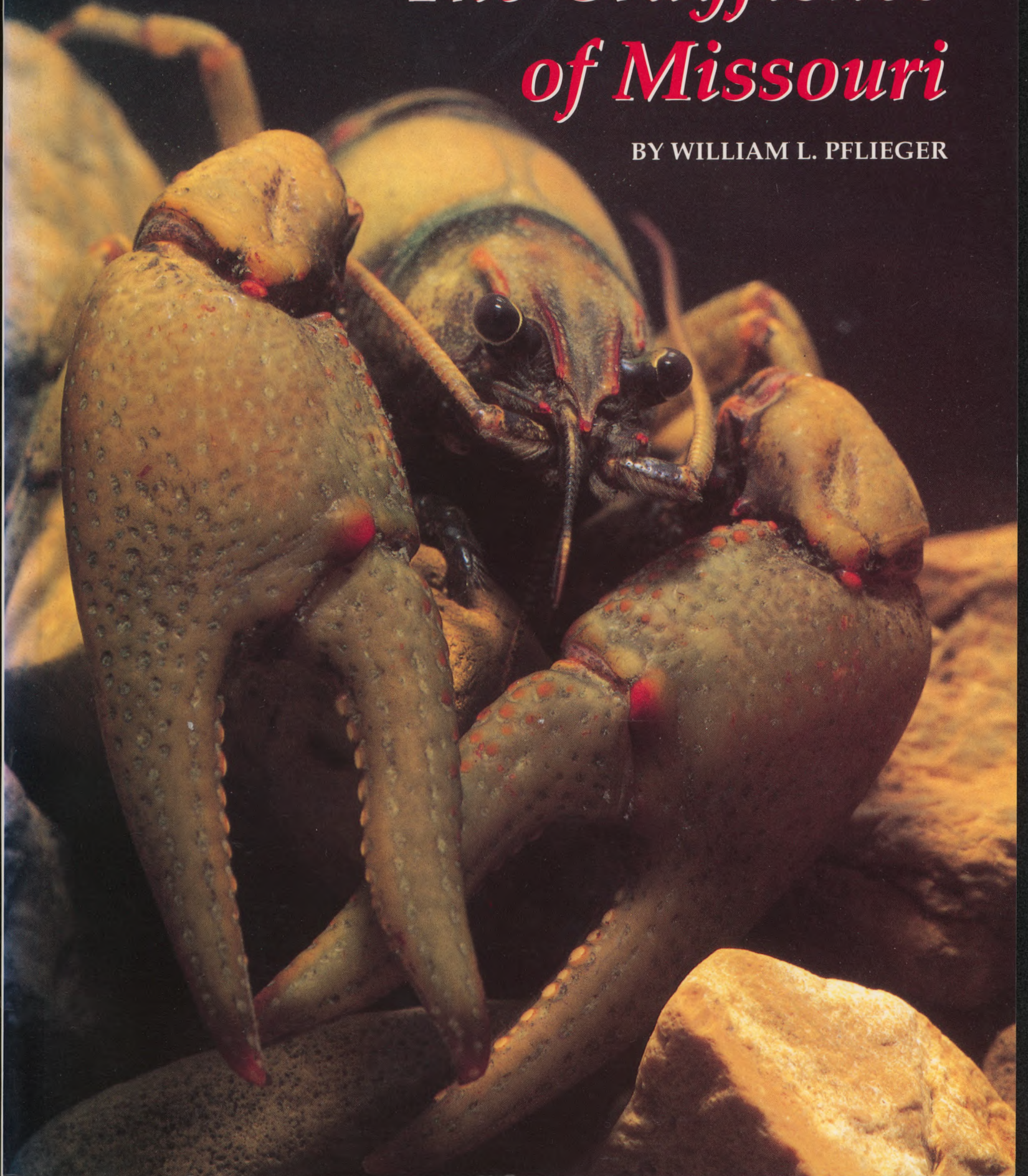


The Crayfishes of Missouri

BY WILLIAM L. PFLIEGER

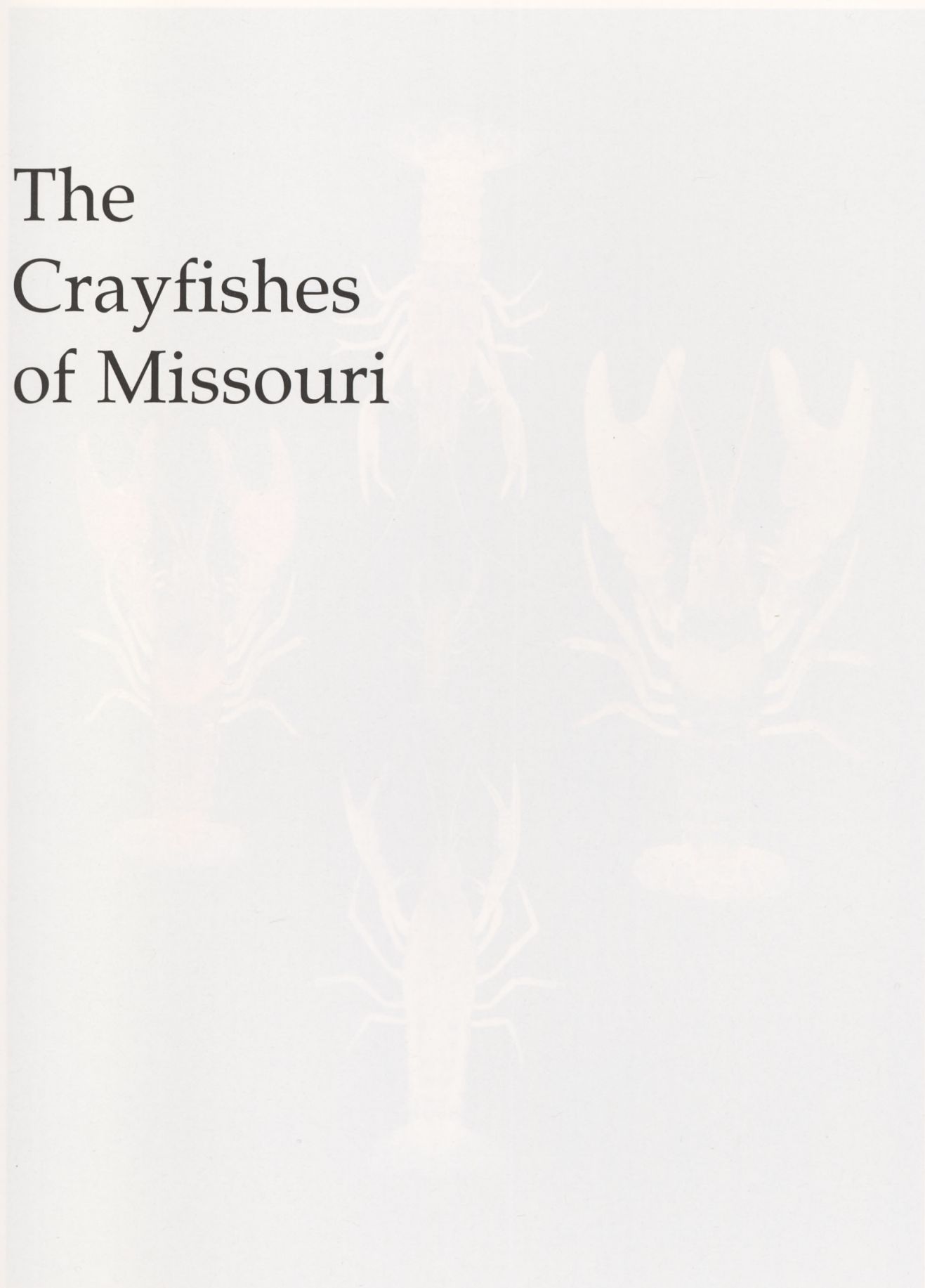






*Cover: The Golden Crayfish, *O. luteus*, is one of the most common crayfish species of the Ozarks.
Photograph by Jim Rathert.*

The Crayfishes of Missouri





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by William L. Pflieger

Bernadette Dryden, editor

Scott Faiman, illustrator

Photographs by the author, unless otherwise credited

published by the Missouri Department of Conservation



William Reston

Unusual red color variant of unidentified juvenile crayfish; Finley Creek, Christian County

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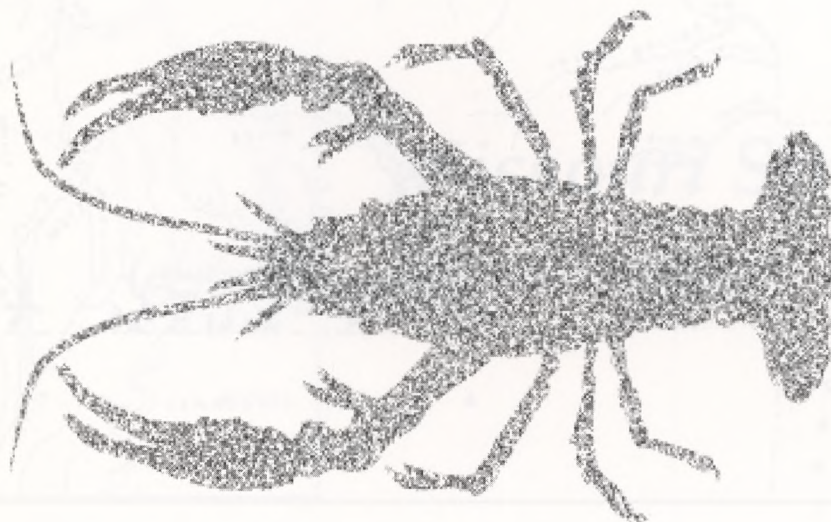
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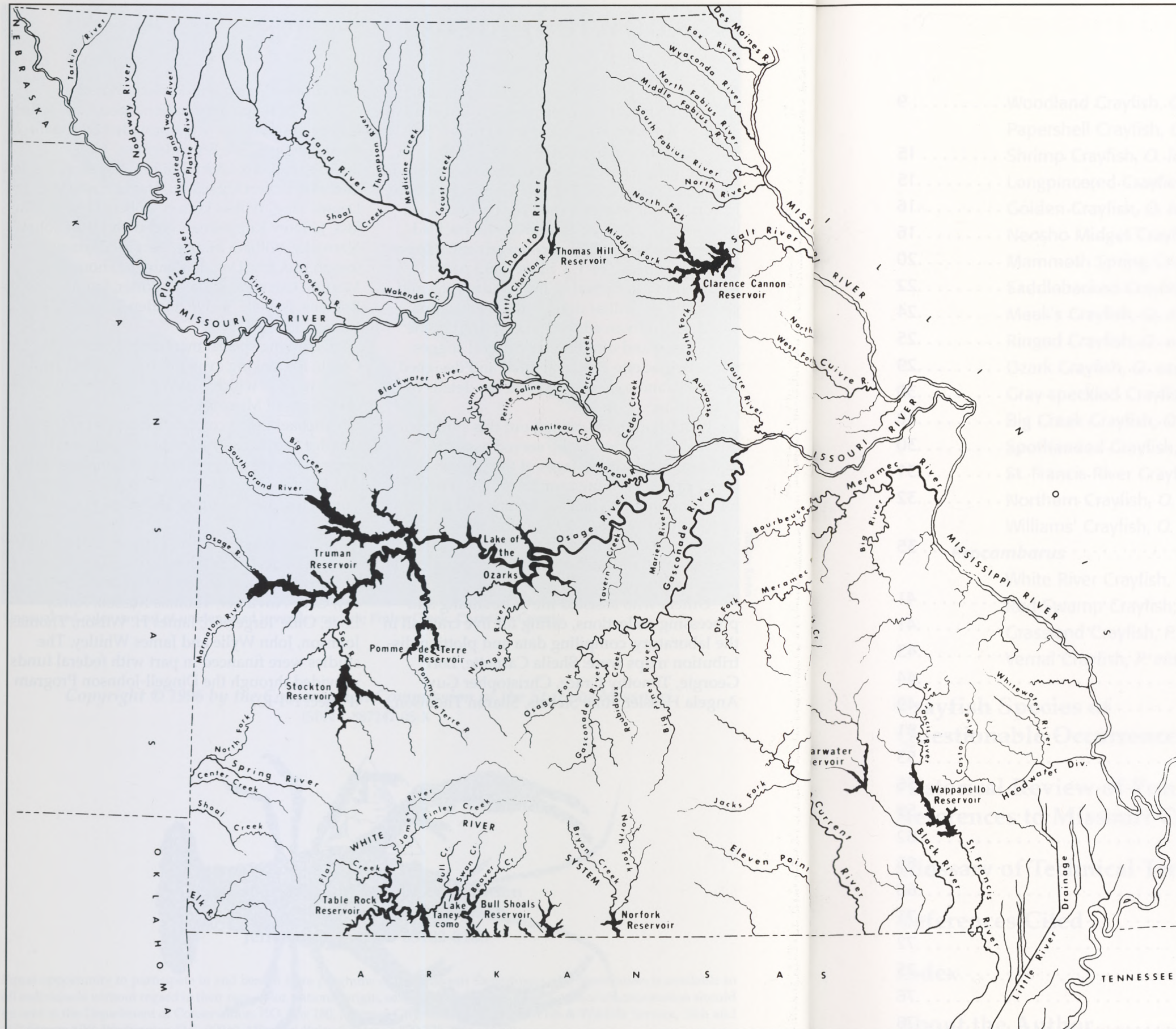
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Missouri Stream Drainages

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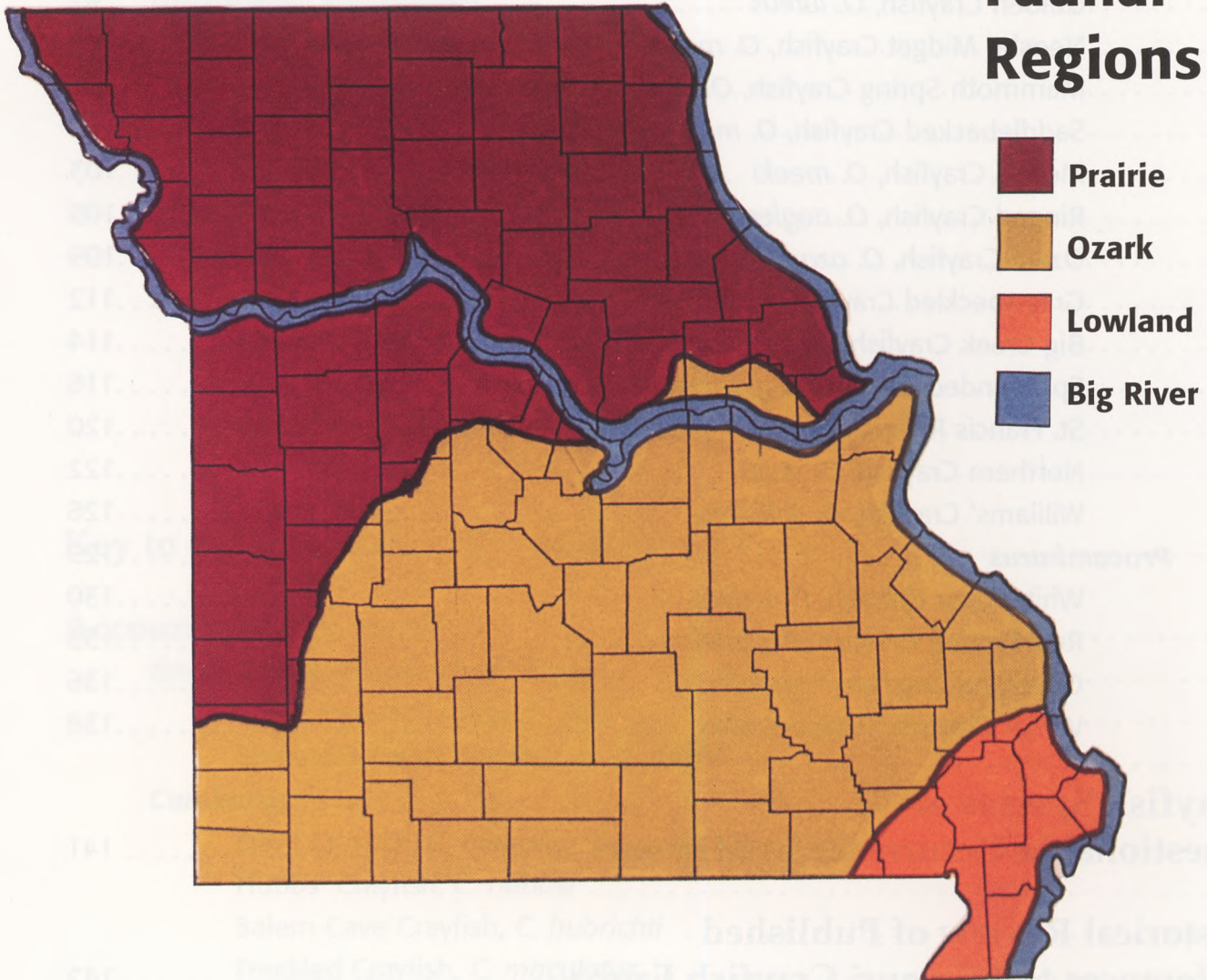
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Aquatic Faunal Regions



Introduction to the Crayfishes

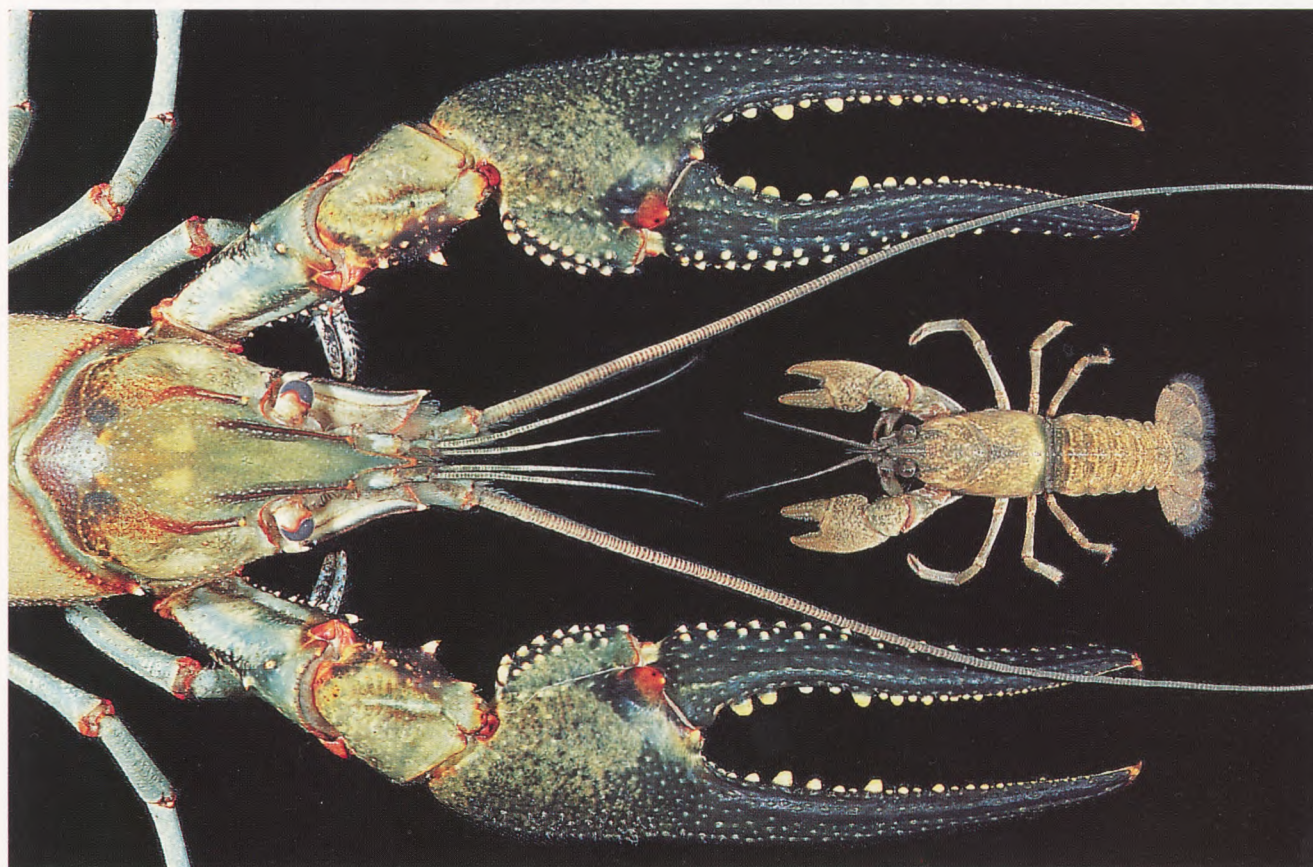
Place in the Animal Kingdom

Crayfish, also called crawfish or crawdads, are members of a large and successful group or **Phylum** of invertebrates known as **Arthropods**. Most arthropods, including such familiar animals as insects, spiders and sowbugs, are characterized by a hard but flexible external shell or *exoskeleton*. Crayfish are further classified as members of the Class **Crustacea**, consisting of arthropods that breathe with gills and have two pairs of antennae. With few exceptions, all crustacea are aquatic and most are marine. Crayfish are further classified in the Order **Decapoda**, which is also mostly marine and includes shrimp, crabs and lobsters. The latinized term "decapod" translates literally to mean "ten-footed," referring to the five pairs of jointed or segmented legs possessed by all decapod crustacea.

Crayfish are such familiar animals that they

are not likely to be confused with other invertebrates which occur in Missouri. Adult crayfish are relatively large compared with other Missouri invertebrates, with an adult body length of one to six inches. The body and appendages are heavily armored and conspicuously jointed. The first pair of body appendages or "legs" consists of greatly enlarged pincers referred to technically as *chelipeds*. The front half of the body is covered by an unjointed shell or *carapace*, while the posterior half or *abdomen* has seven segments, including a conspicuous tail fan.

The only other decapods which occur in Missouri are two species of freshwater shrimp. One of these, the glass shrimp (*Palaemonetes kadiakensis*), is very common. The other species (*Macrobrachium ohione*) was thought to be extinct in Missouri until rediscovered recently in the Mississippi River. In shrimp, only the first two pairs of legs have pincers, while in



The largest and one of the smallest crayfish species found in Missouri are the longpincered crayfish, *Orconectes longidigitus* (left) and the Neosho midget crayfish, *Orconectes macrus* (right).

crayfish the third pair of legs also has pincers. The abdomen or tail of shrimp is flattened from side to side, while that of crayfish is flattened from top to bottom.

Nearly 450 species of crayfish occur worldwide and more than 320 of these are found in North America. The majority of North American crayfish, including virtually all species in the United States east of the Rocky Mountains, belongs to the family **Cambaridae**. This family includes 10 genera of crayfish. At least 32 species of crayfish, classified into six genera, occur in Missouri. Our crayfish fauna is dominated by the genus *Orconectes*, with 19 species. Other genera represented in our fauna are: *Cambarus* (five species), *Procambarus* (four species), *Cambarellus* (two species), *Fallicambarus* (one species) and *Faxonella* (one species).

Distribution and Habitat

The crayfish fauna of Missouri is more diverse than that of most neighboring states. Each species occurs only in certain natural settings or **habitats** that reflect its special requirements. The diversity of crayfish in our state is a result of the variety of habitats that occurs here, and the ability of the crayfish to use these habitats through adaptations in their habits and requirements.

Based on habitat preferences, Missouri crayfish can be divided into four broad categories: 1) **stream dwellers** — crayfish living in surface waters having a noticeable current or flow for much of the year; 2) **swamp, marsh and pond dwellers** — crayfish living in surface waters without noticeable current or flow; 3) **cave dwellers** — crayfish living in underground streams and lakes; and 4) **burrowers** — crayfish living most of the time in tunnels they dig in the ground, sometimes at considerable distances from surface waters.

These categories overlap to some extent. For example, some species habitually occur in seasonally flooded areas of standing water during winter and early spring, retiring to burrows as these surface waters dry up in late spring and summer.

The diversity of aquatic habitats found in Missouri results primarily from the varied physical features of our state. Missouri has four

principal aquatic faunal regions — **Ozark, Lowland, Prairie and Big River** — each with its own characteristic assemblage of crayfish and other aquatic species. Although some species are found in more than one region and others have only a very local occurrence, these four regions serve to identify the typical crayfish habitats and centers of distribution.

Ozark Faunal Region

The Ozark Region, with 25 species, supports by far the greatest variety of crayfish, including seven that are not known to occur outside Missouri and an additional 12 species that have only a limited distribution in some neighboring states. The richness of this fauna is a result not only of the varied aquatic habitats of the Ozarks, but also of the landscape and drainage patterns of its streams which are geologically ancient. These features developed gradually through a process of geologic uplift and erosion of bedrocks laid down by ancient seas millions of years ago.

During the Pleistocene ice ages vast continental glaciers changed the landscape of other sections of Missouri, but left the Ozarks largely untouched. The Ozark Region provided a refuge for crayfish species displaced by the glaciers, and long isolation in various Ozark drainages provided opportunities for development of unique species through a gradual process of adaptation to localized environmental conditions. Historical events, such as extreme droughts that may have eliminated species from some drainages but not from others, also may have played a role in the development of unique crayfish faunas in the various Ozark drainages.

Geologically, the Ozark Faunal Region is a level to rolling plain that was uplifted near the beginning of the Pleistocene ice ages more than a million years ago and subsequently was deeply dissected by the streams that drain it. It is characterized by bedrocks that are older, elevations that are higher, and topography that is more rugged than surrounding regions. Limestones and dolomites laid down by ancient seas underlie much of the Ozarks, but these bedrocks surround a tract of granite knobs, the St. Francis Mountains, in the southeastern part



Bourbeuse River, Franklin County — Ozark Faunal Region

of the region. Occasional exposures of sandstone and shale occur elsewhere. Elevations in the Ozarks commonly exceed 1,000 feet and the tops of hills often stand 300 feet or more above the beds of nearby streams.

The streams typically occupy narrow, steep-sided valleys and their channels are a series of well defined riffles, runs and pools. Chert or flint that is highly resistant to erosion occurs in great quantities in bedrock of the region and the coarse, angular chert fragments are a major component of the stream substrates. The highly soluble limestone and dolomite bedrocks are honeycombed by an extensive network of subterranean stream channels that manifest themselves at the surface as sinkholes, caves and springs. The thin, stony soils of the Ozarks contribute little fine sediment to surface runoff. Consequently, Ozark streams tend to be relatively clear and cool, with well sustained base flows.

Although all Ozark streams drain ultimately into the Mississippi River, they do so by diverse routes. Since stream crayfish do not ordinarily travel far overland, they must have continuous waterways for their dispersal. From a crayfish's point of view, streams only a few miles apart by an overland route might as well be hundreds,

or even thousands of miles apart. For a crayfish in the James River, Webster County, to disperse through continuous waterways into the Niangua River of the same county would require a trip of more than 1,500 miles by way of the White, Mississippi, Missouri, and Osage rivers. Crayfish faunas in the James and Niangua rivers have evidently been separated for thousands, perhaps millions of years, because they have no species in common except for the northern crayfish (*O. virilis*), and it likely was introduced into James River as a bait-bucket release at a relatively recent date.

Of the 25 species of crayfish that have been recorded in the Ozarks, 17 are *Orconectes*, five are *Cambarus*, two are *Procambarus*, and one is *Fallicambarus*. Sixteen of these species, all in the genera *Cambarus* and *Orconectes*, are not known to occur outside the boundaries of the Ozark Region of Missouri and adjoining states. These are: Hubbs' crayfish (*C. hubbsi*), Salem cave crayfish (**C. hubrichti*), freckled crayfish (**C. maculatus*), bristly cave crayfish (*C. setosus*), coldwater crayfish (*O. eupunctus*), belted crayfish (**O. harrisoni*), woodland crayfish (**O. hylas*), longpincered crayfish (*O. longidigitus*), Neosho midget crayfish (*O. macrus*), Mammoth Spring crayfish (*O. marchandi*), saddlebacked

crayfish (**O. medius*), Meek's crayfish (*O. meeki*), Ozark crayfish (*O. ozarkae*), Big Creek crayfish (**O. peruncus*), St. Francis River crayfish (**O. quadruncus*), and Williams' crayfish (*O. williamsi*). The seven species marked with an asterisk have never been recorded outside Missouri. Three additional species have only a very limited distribution outside the Ozarks. These are: golden crayfish (*O. luteus*), ringed crayfish (*O. neglectus*), and spothanded crayfish (*O. punctimanus*). A subspecies of the ringed crayfish (*O. n. chaenodactylus*) occurs only in the Ozarks. Of the remaining six species recorded in the Ozarks, only the devil crayfish (*C. diogenes*) and northern crayfish are relatively common and widespread. The digger crayfish (*F. fodiens*), gray-speckled crayfish (*O. palmeri*), white river crayfish (*P. acutus*), and grassland crayfish (*P. gracilis*) are represented in the Ozarks by only a few populations. All of these six species are much more common in adjoining sections of the Prairie or Lowland faunal regions.

Ecologically, the Ozark crayfish fauna is dominated by **stream dwellers**. Eighteen species are in this category. Most of them reach their greatest abundance in riffles, runs, and the margins of pools where they tunnel in gravel substrate or dig cavities beneath rubble and boulders. Species living in finer gravel, such as the Neosho midget crayfish, are smaller than those living in coarser substrates like the ringed crayfish and Ozark crayfish.⁶ Two of the larger species, spothanded and northern crayfish (*O.*

virilis), are more often found in pools and backwaters among beds of aquatic vegetation such as water willow (*Justicia*) or spatterdock (*Nuphar*) or in deposits of organic debris. The largest of all Missouri crayfish species, the long-pincer crayfish, lives in deep pools along bluffs where rock slabs and boulders provide crevices for hiding.

The **cave dwellers** among Missouri crayfish, the Salem cave crayfish and bristly cave crayfish, are confined strictly to the Ozarks. These blind, white crayfish are most often observed in cave streams but are also found among rocks at the entrance of springs, or occasionally in streams and springfed swamps after heavy floods have flushed them from their preferred habitat.

Three species of **burrowers** are represented in the Ozark crayfish fauna, but all are rare and localized. The devil crayfish occurs sporadically along the flood plains of major streams in the eastern Ozarks where the water table is high and fine, and deep alluvium is favorable for burrowing. A population of the digger crayfish occupies similar habitat near the Gasconade River in Gasconade County. The grassland crayfish has been recorded occasionally in native prairies along level upland divides in the western Ozarks.

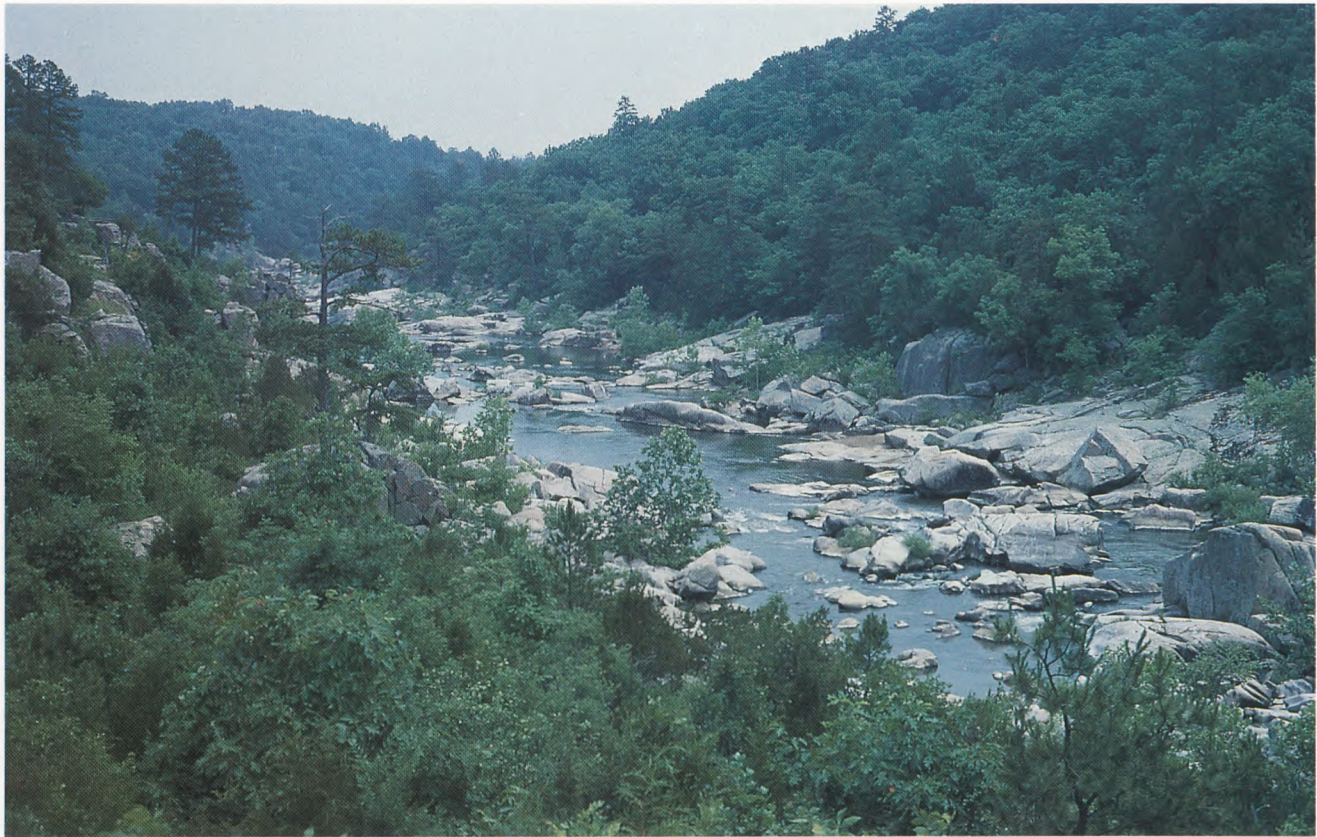
A few populations of the white river crayfish have penetrated for short distances into the Ozarks along its boundary with the Lowland Faunal Region, but otherwise the **swamp, marsh and pond dwellers** are not found in the Ozark crayfish fauna.

Striking differences in crayfish faunas of the various Ozark drainages is the rule rather than the exception, and a general discussion of Ozark crayfishes must include a consideration of these differences. The reader who is unfamiliar with drainage patterns in the Ozarks is referred to the map immediately preceding the Table of Contents.

The Osage River Basin has the least diverse and distinctive crayfish fauna of any major drainage in the Ozark Region. The only common stream species in the Osage Basin are the northern crayfish, a species with a wide distribution outside of the Ozarks, and the golden crayfish, one of the most widely distributed Ozark species. The bristly cave crayfish is known from a few subterranean streams in



Barn Hollow, Texas County — Ozark Faunal Region



St. Francis River, Madison County — Ozark Faunal Region

headwaters of the Sac River, and the Salem cave crayfish has been recorded from Hahatonka Spring.

In the Gasconade River Basin the northern crayfish is replaced by the spothanded crayfish, but the fauna is otherwise similar in general composition to that of the Osage. The Salem cave crayfish has been recorded from four Gasconade Basin localities. The burrowing crayfishes, devil crayfish and digger crayfish, are each known from a single locality in the Gasconade Basin.

The nine crayfish species in Meramec Basin include the freckled crayfish and saddlebacked crayfish that occur nowhere else in the world. The belted crayfish is almost as restricted, having been recorded only once outside the Meramec Basin. This locality is the St. Francis River where it possibly was introduced. None of the three species listed above occur in the Bourbeuse River or Dry Fork subdrainages of the Meramec Basin. The woodland crayfish is found in headwater streams of the southern part of the basin. The Salem cave crayfish is known from Meramec Spring and a nearby cave. The golden crayfish and spothanded cray-

fish are common and generally distributed in the Meramec Basin. The northern crayfish and devil crayfish are widely distributed, but less abundant.

Direct tributaries of the Mississippi River between the Meramec River and Cape Girardeau, including the Headwater Diversion, have a rather limited crayfish fauna. The golden crayfish and northern crayfish are the only widely distributed species. In the drainages of Apple Creek and the Headwater Diversion they are joined by the digger crayfish and spothanded crayfish. In the latter drainage two Lowland species, gray-speckled crayfish and white river crayfish, occur.

The St. Francis River crayfish and the Big Creek crayfish are endemic to the St. Francis River Basin, never having been recorded elsewhere. They are dominant species in small streams of the basin. The golden crayfish and Hubbs' crayfish are widespread and common. The northern crayfish, possibly introduced, and spothanded crayfish occur sporadically in the St. Francis River Basin. An introduced population of the woodland crayfish (*O. hylas*) occurs in Stouts Creek at Ironton and a population of

the belted crayfish (*O. harrisoni*) that may have been introduced occurs in the St. Francis River at Sam Baker State Park.

Throughout the basin of Black River the dominant species is the woodland crayfish, a species otherwise native only to a few streams of the Meramec. Other common and widespread species in this basin are Hubbs' crayfish and the spothanded crayfish. The devil crayfish and gray-speckled crayfish occur sporadically and the northern crayfish was recorded below Clearwater Dam.

In Current River Basin the common crayfish are Hubbs' crayfish, golden crayfish, Ozark crayfish and spothanded crayfish. The Salem cave crayfish occurs at several localities. A population of the northern crayfish that is probably introduced occurs in Current River below Montauk Spring, and the devil crayfish and white river crayfish have been collected at a few localities along lower Current River.

The dominant crayfish species in Eleven Point River, except its headwaters, is the cold-water crayfish. This species occurs nowhere else in the world except the adjacent Spring River Basin. Other common crayfish in the Eleven Point River Basin are Hubbs' crayfish, Ozark crayfish and spothanded crayfish. The Salem cave crayfish has been recorded from four localities.

The Mammoth Spring crayfish is known in Missouri only from the Warm Fork near Thayer, Oregon County, and is otherwise known to occur only in two adjacent counties of Arkansas. The fauna of Spring River Basin is in other respects similar to that of the adjacent Eleven Point River.

The dominant crayfish species throughout the White River Basin is the ringed crayfish. A distinct subspecies (*O. n. chaenodactylus*) occurs in pure form only in the North Fork and Bryant Creek, intergrading westward in the White River Basin with subspecies *O. n. neglectus*. The longpincered crayfish is a large, spectacular crayfish that occurs widely in the White River Basin but nowhere else. Two smaller and more localized species, Meek's crayfish and Williams' crayfish, are restricted to the headwaters of White River. Hubbs' crayfish and the spothanded crayfish are uncommon and occur sporadically in the basin. The bristly cave crayfish occurs widely in cave streams in the western

part of the basin. The northern crayfish has been introduced.

Three common, widespread crayfish species occur in the Neosho (Spring and Elk) River Basin of the southwestern Ozarks. These are the Neosho midget crayfish, ringed crayfish and northern crayfish. The bristly cave crayfish occurs widely in subterranean streams and the grassland crayfish has been recorded in upland prairies.

Lowland Faunal Region

The Lowland Faunal Region in Missouri's "bootheel" is set off from the adjacent Ozark Region to the north and west by an abrupt change in elevation of 50 to 250 feet. As its name implies, elevations in the Lowland Region are generally low, less than 350 feet above sea level. The region as a whole is a broad plain sloping gradually from north to south. Bedrock is exposed at the surface only in Crowley's Ridge, the only prominent topographic feature in the lowlands. Elsewhere, bedrocks are covered to depths of as much as 200 feet by sediments, mostly sands and silts, laid down by the Mississippi River and other streams.

Prior to settlement, the lowlands was mostly cypress swamps and sloughs interspersed with low, sandy ridges. Several Ozark rivers,



Unnamed ditch, Scott County — Lowland Faunal Region



Allred Lake, Butler County — Lowland Faunal Region

including the Black, St. Francis, Castor, and Whitewater entered the lowlands from the north and pursued meandering courses southward to the Mississippi. The Castor and Whitewater joined to form Little River, which drained the central part of the lowlands. In the early 1900s the Headwater Diversion Channel was dug to divert Ozarkian portions of the Castor and Whitewater eastward towards Cape Girardeau, effectively disrupting the flow of Little River. An extensive network of ditches was dug to drain the swamps in Little River Basin and other stream drainages.

The only extensive areas of swamp that remain are in public ownership, including Mingo Swamp, Duck Creek, Otter Slough and Big Oak Tree State Park. Seasonally flooded roadside ditches and sloughs are other important standing water habitats for lowland crayfish. Flowing waters include nearly 1,200 miles of ditches and the remaining natural streams, such as the St. Francis and Black rivers. These flowing waters vary greatly in volume, current and clarity. The sands and gravels underlying

the Lowlands are excellent aquifers and many of the ditches have well-sustained base flows. Substrates consist of silt, sand, and small gravel, depending on the amount of current. Thick growths of aquatic vegetation are present in the clearer ditches. The swamps and other standing-water habitats are subject to wide seasonal fluctuations in area and depth. Some are entirely dry for part of the year. Silt and organic debris are principal substrates in standing-water habitats.

The Lowland Faunal Region supports a small but distinctive crayfish fauna of 10 species. The genera *Orconectes* and *Cambarus*, which dominate the Ozark crayfish fauna, are represented in the lowlands by only two species and one species, respectively. There are three species of *Procambarus*, two species of *Cambarellus*, and one species each of *Fallicambarus* and *Faxonella*. Six of the lowland species are near the northern limit of their distribution in southeastern Missouri, occurring southward along the Mississippi River to the Gulf Coast. These are the Cajun dwarf crayfish,



Roadside slough, New Madrid County — Lowland Faunal Region

(*C. puer*), shield crayfish (*F. clypeata*), shrimp crayfish (*O. lancifer*), gray-speckled crayfish (*O. palmeri*), red swamp crayfish (*P. clarkii*), and vernal crayfish (*P. viaeveridus*). Shufeldt's dwarf crayfish (*C. shufeldtii*) is similarly distributed, except for the occurrence of a few populations on the flood plain of the Mississippi River north of St. Louis. The remaining three lowland species have a widespread distribution in the northern and eastern United States, but only the devil crayfish (*C. diogenes*) is well represented in other faunal regions of Missouri. The digger crayfish (*F. fodiens*) is known outside the lowlands only from a single Ozark locality. The white river crayfish (*P. acutus*) penetrates for a short distance into the southeastern Ozark Faunal Region where it borders the Lowland and occurs in north Missouri at a few localities along the Upper Mississippi, Chariton, and Grand rivers.

Although most lowland crayfish are **swamp, marsh and pond dwellers**, nearly all of them burrow at least to some degree. The dwarf crayfish (*C. puer* and *C. shufeldtii*) appear to resort to burrowing only to escape drying, and are quite capable of completing their life cycle in surface waters. The white river crayfish and red swamp crayfish likewise spend much of the year in surface waters, but burrow at certain times of the year to breed and reproduce, even when surface waters are available. Most individuals of the shield crayfish and the vernal crayfish are in temporarily flooded areas during late winter and spring, but retreat to burrows for the remainder of the year. The strong ten-

dency to burrow exhibited by species of this group permits them to colonize the extensive, seasonally flooded habitats that cannot support crayfish requiring permanent surface waters.

The devil crayfish and digger crayfish are the true **burrowers** among the lowland species. Most adults of these species are in burrows at all times of the year, even when an abundance of surface water habitat is available. However, females often enter surface waters to drop their young, and these young may remain in surface waters for much of their first summer.

The gray-speckled crayfish did not occur in standing waters in my collections and clearly qualifies as the strict **stream dweller** among the lowland crayfish. The shrimp crayfish occurs in deep, permanent oxbows and large rivers, and perhaps is also best classified as a stream dweller.

Except for a few hardy species such as the gray-speckled crayfish and white river crayfish that seem to thrive in ditches and other disturbed habitats, there is a tendency for most crayfish species to avoid the central, more intensively cultivated sections of the lowlands, with most distribution records clustered to the west along the St. Francis, Black and Little Black rivers, or to the east along the Mississippi River. This type of distribution pattern is exemplified by the two species of dwarf crayfish (*Cambarellus*), the shield crayfish, the digger crayfish and vernal crayfish. Perhaps these species were more generally distributed and abundant in the lowlands before they were ditched and drained.

Prairie Faunal Region

This faunal region includes most of Missouri north of the Missouri River and a wedge-shaped area south of the river between the Ozarks and the Kansas state line. Topographically, the Prairie Region is broadly characterized as a flat to rolling plain, with belts of low hills along the major streams. The bedrocks underlying the region are mostly shales and thin sandstones, but limestones predominate to the east along the Mississippi and lower Missouri rivers. Till and loess associated with glaciation overlie the bedrocks in extensive areas along and north of the Missouri River.



Paul Childress

(Above) Grand River, Grundy County; (Below) Little Drywood Creek, Vernon County — both in Prairie Faunal Region

The major streams occupy broad valleys and originally meandered across their broad flood plains, leaving many oxbows and sloughs as their courses changed. Many streams have been channelized. Sand and silt are principal substrates in the streams, but gravel, rock and occasional outcrops of bedrock are prevalent in some areas. Unchannelized streams typically consist of long, deep pools and occasional short riffles and runs. Compared with Ozark streams, Prairie streams are more turbid and silty, with less constant flows.

The Prairie crayfish fauna is quite limited. Only seven species are known from this region. The northern crayfish (*O. virilis*) is by far the most abundant. The devil crayfish (*C. diogenes*), papershell crayfish (*O. immunis*) and grassland crayfish (*P. gracilis*) are common in suitable habitats throughout the region. The golden crayfish (*O. luteus*) is restricted to tributaries of the lower Missouri and upper Mississippi rivers where it is locally common. The spothanded crayfish (*O. punctimanus*) occurs in a few prairie streams of Callaway and Montgomery counties. The white river crayfish (*P. acutus*) is known





Petite Saline Creek, Cooper County — Prairie Faunal Region

from two localities along the Chariton and Grand rivers.

The northern crayfish, spothanded crayfish, and golden crayfish are typically **stream dwellers** while the papershell crayfish and white river crayfish are primarily **swamp, slough** and **pond dwellers**. Like most members of the group, the latter two species typically

occur in habitats subject to wide seasonal fluctuations in area and depth, and they exhibit a strong tendency to burrow. The devil crayfish and grassland crayfish are **burrowers**, with the former species typically found in timbered or formerly timbered areas along streams and the latter species in grasslands or former grasslands, sometimes at considerable distances from surface streams.

Big River Faunal Region

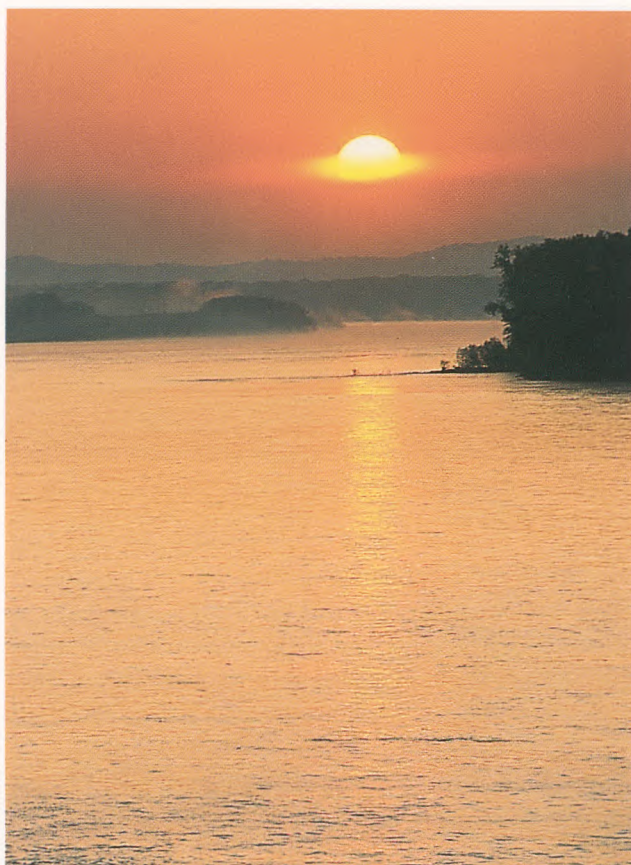
This aquatic faunal region includes the Missouri and Mississippi rivers and standing waters along their flood plains. These flood plains vary in width from two to 10 miles, but in southeastern Missouri blend almost imperceptibly into the Lowland Faunal Region. Standing waters, varying from large, permanent oxbow lakes to small, seasonal sloughs are common on the flood plains. Many kinds of fish are found in river channels, but crayfish occur in this habitat only as small local populations or stray individuals.

However, crayfish are often abundant in



Missouri River — Big River Faunal Region

Jim Rathert



Mississippi River, Cape Girardeau County — Big River Faunal Region

standing-water habitats on the river flood plains. No crayfish species are limited to or especially characteristic of the Big River Faunal Region. Shufeldt's dwarf crayfish (*C. shufeldtii*) and the white river crayfish (*P. acutus*) occur along the upper Mississippi River flood plain. The devil crayfish (*C. diogenes*) and papershell crayfish (*O. immunis*) are widely distributed along the Mississippi and Missouri rivers. The northern crayfish (*O. virilis*) occurs in the lower reaches of tributary streams on the river flood plains, but is not common.

As indicated in the discussion of these species in other faunal regions, most tend to burrow — including some species that burrow only to escape drying or freezing and others in which burrowing is an essential feature of their life cycle.

Structure and Life Ways

The body of a crayfish is encased in a rigid armor, the **exoskeleton**, composed of a material called **chitin**. Calcium salts are an important

ingredient of chitin that gives it rigidity. The exoskeleton serves to protect the crayfish from predators and other hazards and also provides a framework for anchoring the underlying soft parts. Even though the crayfish is encased in armor it enjoys considerable freedom of movement because the body and its appendages are divided into segments or sections that are connected by flexible joints. The body of a crayfish consists of two distinct sections, an anterior or front section called the **cephalothorax** and a posterior or rear section called the **abdomen**.

The cephalothorax is covered by a unified, unjointed shell, the **carapace**. A conspicuous transverse **cervical groove** divides the cephalothorax into the **head** and **thorax**. The most conspicuous features of the head are the eyes and two sets of antennae or feelers. The eyes are on stalks, and each eye consists of thousands of structures called **omotidia** that each function like a separate eye, providing the crayfish with a mosaic view of its world. The inner pair of antennae, called **antennules**, are much shorter than the outer pair and each consists of two branches or forks. The antennae and antennules function as the senses of touch and smell. Beneath the antennules are flattened bladelike structures, the **antennal scales**.

The mouth parts of a crayfish consist of five pairs of overlapping structures, each with its own role in crushing and shredding the food before it is ingested. The largest of these structures are the heavy toothlike mandibles.

The body parts underlying the carapace include a series of plumelike gills. These are situated within a gill chamber on each side of the body and extract oxygen from water or air. A pair of large flaps attached to the mouth parts extend into the gill chambers. These **gill balers** undulate to create a water current that enters the gill chambers from below and exits towards the head. This current can be reversed periodically to flush away debris that may accumulate on the gills.

The **thorax** is the midsection of the crayfish between the head and the abdomen. Extending forward from the front of the thorax are the large **chelipeds** or pincers. The pincers function in capturing food, in defense, and in social interactions. Behind the chelipeds and extending more or less laterally from the thorax are four pairs of walking legs. The first two pairs

are tipped with small pincers that are used in grooming and to manipulate the food.

The **abdomen** of the crayfish is commonly referred to as the tail. Unlike the carapace, the abdomen is jointed and flexible, consisting of seven distinct segments. The last abdominal segment is further divided and expanded into several flattened, scalelike structures that together form the **telson** or **tail fan**. When the crayfish is in a hurry, large muscles within the abdomen are contracted to curl the tail fan forward beneath the body in a series of rapid jerking motions. The tail fan functions as an oar, which causes the crayfish to dart rapidly backward, often rising well above the stream or lake bottom.

These brief swimming bouts occur primarily when the crayfish wants to escape predators. At other times the crayfish proceeds forward on its four pairs of walking legs, with the pincers held above the stream or lake bottom and stretched out in front. When threatened, the crayfish assumes a characteristic "defense posture" with the front part of the body elevated and the pincers spread to their maximum extent. At such times the crayfish may retreat by walking slowly backward.

Although some crayfish species are active throughout the day, as a group they tend to be nocturnal. The longpincered crayfish, for example, is rarely seen in the open in the daytime unless disturbed, but prowls the pools of Ozark streams at night in search of food or mates.

The food habits of few of the crayfish species that occur in Missouri are known in detail. Crayfish, in general, are considered to be **omnivores**, and feed opportunistically on a wide variety of plant and animal materials. They are an important link in the food chain between plants and vertebrates, breaking down dead plant material (detritus) that is resistant to decomposition. Crayfish are an important food for many animals that occur around or in water, including fish, snakes, turtles, wading birds, raccoons and mink.

Since the crayfish is encased in a rigid exoskeleton or "shell," growth presents special problems not encountered by animals with a thin, flexible skin. The crayfish must periodically discard the old shell and replace it with a new and larger one. The process is called **molting**. The new shell develops beneath the old one over a period of weeks. When it is com-



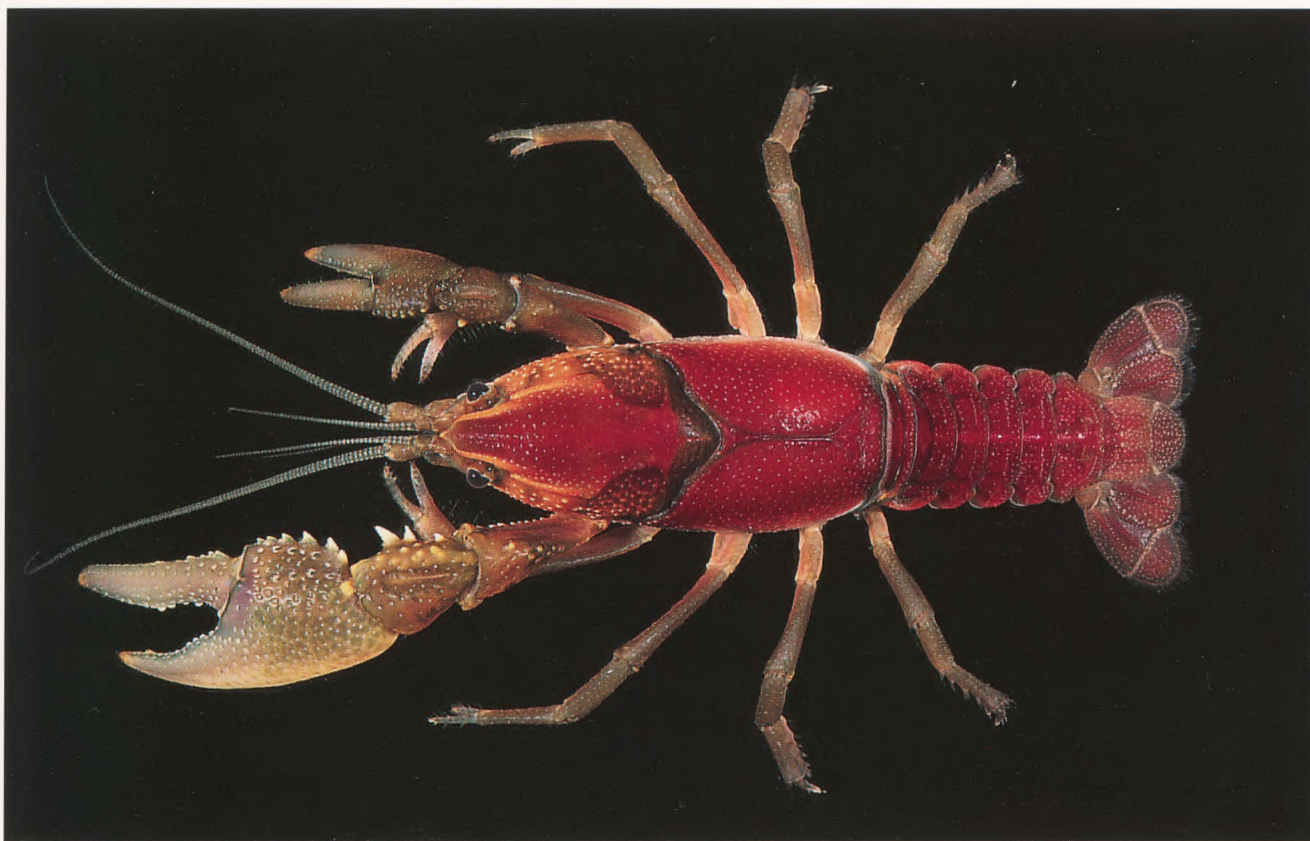
Spot-handed crayfish, *Orconectes punctimanus* (bottom), and its molted shell (top)

plete, the old shell splits along the connection between the carapace and abdomen and the entire body is withdrawn through this opening. Even the covering of the antennae and eyes, as well as the lining of the stomach, are left with the old shell.

The freshly exposed new shell is soft, requiring as long as 10 days to develop the hardness of the old one. During this period the crayfish is very vulnerable to predation and even to cannibalism by other crayfish. For this reason the crayfish retires to some protected place such as a cavity beneath a rock or log in preparation for molting.

An interesting aspect of molting in crayfish is the gradual development between molts of two whitish stones or **gastroliths** between the wall and chitinous lining of the stomach. These reach maximum size just prior to molting. When the stomach lining is shed, they drop into the stomach and are slowly dissolved by digestive enzymes. Since these gastroliths are composed of the calcium salts required for hardening the new exoskeleton, they play an essential role in the molting process.

Molting appears to be stressful to crayfish and sometimes they die halfway out of their old shell. At other times one or more appendages, frequently the pincers, are left behind. Crayfish have a remarkable ability to regenerate lost appendages, including pincers. However, several molts are required for the regenerated pincer to attain the size of the original. Even then it never has the exact shape and sculpting of the original. This is why it is very common to see crayfish with pincers that are



Grassland Crayfish, *Procambarus gracilis*, with a regenerated pincer (right)

unlike in size, shape and sculpting.

Crayfish molt frequently during their first summer of life; for example, as many as 14 times in the dwarf crayfish.³ Growth and molting cease in winter, but typically there is a general, and more or less simultaneous, molt by most members of a population as water temperatures rise in spring. However, molting in females brooding eggs or young may be delayed as much as three weeks compared to the rest of the population. Adults of many species molt twice during their second year — the second molt coming in late summer or fall just prior to the breeding season.

The usual life span in the majority of crayfish species occurring in Missouri is one to three years, with occasional individuals living four or five years. However, some burrowing species and those adapted to subterranean waters may live considerably longer.

Males of crayfish in the family Cambaridae, which includes all the species found in Missouri, exhibit a cyclic dimorphism associated with reproduction. With few exceptions, the Missouri species have a fairly restricted breeding season during which most adult males are

in a reproductively active or **Form I** condition. Typically, these Form I males molt into a reproductively inactive, or **Form II** condition, during the next molt following the breeding season. Since many species have a fall breeding season and do not molt in winter, reproductively active males typically remain in the Form I condition until the following spring.

There are a number of morphological differences between Form I and Form II males, but those involving the reproductive structures called **gonopods** are the most striking. The gonopods are a pair of rodlike structures which extend forward between the bases of the walking legs from their point of attachment on the underside of the first abdominal segment. Form I males are distinguished from Form II and juvenile males by the presence of a corneous (yellowish translucent) tip on one or more of the terminal processes of the gonopod. Also, the processes are longer and have more pointed tips in Form I males. In Form II and juvenile males the gonopod processes are shorter, blunter, and are entirely of a uniform texture.

Another feature of adult male crayfish is the presence of hooks on some of the walking legs.



Golden crayfish, *Orconectes luteus*, mating pair

In all species these are present on the inside bases of the second pair of walking legs, and in some species hooks are also present on the first or third pair. These hooks are large and well defined in Form I males, somewhat developed in Form II males, and absent in females.

Female crayfish have a pocketlike sperm receptacle, also called the **annulus ventralis**, located between the bases of the last two pairs of walking legs. In most species the sperm receptacle has a central depression or **fossa**, but this does not open into the body of the female.

Mating in crayfish occurs when the male turns the female over on her back. He grasps her chelipeds and walking legs with his pincers, and fits the hooks on the bases of his walking legs into corresponding depressions on the underside of the female, thus locking the two crayfish together. The male gonopods, supported by the second abdominal appendages, are thrust forward with their tips against the sperm receptacle of the female. The mating crayfish remain locked together for an extended period, often an hour or more, during which time the

sperm are transferred from ducts at the bases of the male's last pair of walking legs to the female's sperm receptacle by way of a tube formed by the gonopod and appendages of the second abdominal segment. A gummy substance, the **sperm plug**, is deposited over the sperm receptacle, apparently functioning to retain the sperm and perhaps to prevent the female from mating with other males.

In many species of Missouri crayfish mating occurs in the fall, and the eggs are not released and fertilized until the following spring. This appears to be the case with most of the stream-dwelling species of *Cambarus* and *Orconectes*, with less well defined and more protracted breeding and reproductive seasons in other Missouri species.

When the female is ready to lay her eggs she retreats to a secluded location where she cleans the underside of her abdomen and thorax. When this has been accomplished a sticky substance called "glare" is released from glands in the tail fan to form a membranous sac into which the eggs are released and fertilized. The



(Above) Ozark crayfish, *Orconectes ozarkae*, female carrying eggs (ventral view); (Below) Crayfish young attached to swimmerets of female



William Roston

eggs are attached individually to **swimmerets** on the underside of the abdomen by threads composed of glare.

During the extended period when the female is carrying the eggs and young she protects them by tucking the tail fan forward under the abdomen and aerates them with fanning motions of the swimmerets. The females are relatively inactive and secretive during the incubation period, as indicated by the unbalanced sex ratio and scarcity of adult females in many crayfish collections made in early spring.

The young crayfish remain attached to the swimmerets until they complete two molts. After they are free they begin making brief forays from the female. However, they return to the safety of her abdomen when they feel threatened, clamping themselves to her swimmerets with their pincers.

The juvenile crayfish complete several more molts during their first summer. In many

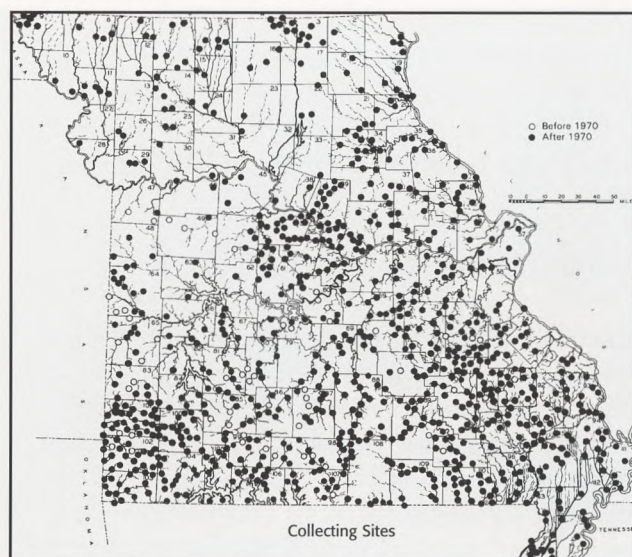
species some individuals mature and mate by late summer or fall of their first year, while others do not mature until their second year. Individuals in their second year of life form the bulk of the breeding population in most species.

Importance to Humans

Crayfish are one of the dominant groups of Macro-invertebrates in the United States, occurring in large numbers in a variety of flowing and standing-water habitats. They are generalists in their feeding relationships and may strongly influence the rates and pathways of energy and nutrient flow in the aquatic habitats where they occur.⁵³ Crayfish are an important food source for many fish;⁶⁰ in the Current and Jacks Fork rivers, crayfish were the principal food item of adult shadow bass⁵⁷ and were co-dominant with fish in the diet of adult small-mouth bass.¹² The hellbender, a large primitive salamander, feeds mainly on crayfish in the North Fork River.⁶² Crayfish are a major item in the diet of bullfrogs in Missouri ponds, lakes and streams.^{51,52} A wide variety of other wildlife species, including snapping turtles, racoons, mink, great blue herons and kingfishers also prey heavily on crayfish.

Crayfish are an important commercial and recreational resource in the United States, since they are widely exploited as food and as fish bait.⁴⁹ The total harvest of crayfish for food in the United States is 53,000 metric tons, of which 90 percent comes from Louisiana.⁵⁰ Historically, approximately half of the harvest has come from wild sources. A recreational fishery for the longpincer crayfish exists in Table Rock Lake, and for this and other species of crayfish in several Missouri streams, including Current River. Burrowing crayfish are a serious agricultural pest in parts of the United States, but few complaints are heard in Missouri.

North American crayfish are a diverse and interesting group, and many species display brilliant colors or striking color patterns.⁵ Missouri crayfish are representative of the North American fauna. They are part of our rich heritage of native wildlife and deserve to be better known and appreciated by the general public.



The Study of Crayfishes

Sources of Information

Unless otherwise credited, the life history and distributional information included in this report is based on more than 900 crayfish collections made in Missouri between 1971 and 1992 by the author, or by other biologists listed under Acknowledgments. Collecting sites are indicated by the plotted symbols on the map above. These data were supplemented by information from published studies. The crayfish bibliography of C.W. Hart, Jr., and J. Clark³⁵ was invaluable for conducting this literature review. In planning and implementing the study, I depended greatly on the pioneering work by E.P. Creaser,^{13,16,17} H.H. Hobbs, Jr.,^{38,39,40} and A.B. Williams.^{88,89}

How the Book is Organized

So the book will be useful to readers with varied backgrounds and interests, technical terms have been kept to a minimum. Those considered essential for clarity or conciseness are defined where first used or in a glossary at the back of the book. Terms used in the identification key and descriptions are illustrated in the diagram of crayfish anatomy (page 34). Streams mentioned in the text are named on the drainage map of Missouri (pages 10-11).

General information on the classification,

anatomy and biology of crayfish has been presented in many invertebrate and general biology texts, but is included in the introductory sections of this book to provide a self-contained reference for readers interested in Missouri crayfish. The expanded discussion of distribution and habitat presented in the "Introduction" will alert users of this book to the crayfish species they can expect to encounter in a particular section of the state and will guide them, it is hoped, in conducting their own field studies.

Most of this book is made up of accounts, illustrations and distribution maps for 32 species of crayfish found in Missouri. The species accounts follow a uniform arrangement, and subheadings make information on a particular topic easier to locate.

Under the "Description" subheading, a list of characters is given that can be used to confirm a field identification or one obtained using the identification key. Technical terms used in describing crayfish are defined in a glossary at the back of the book. Unless otherwise indicated, references to male characters refer to the condition in Form I males. The information provided under "Life Colors" and "Size" also will be useful in making identifications. Length measurements are body length (tip of rostrum to tip of tail fan).

The "Most Like" and "Differs" categories call attention to other crayfish species with which the species under consideration is most likely to be confused.

The illustrations and color photographs are of specimens collected in Missouri. Some species are represented by more than one illustration or photograph to show variation in certain characteristics.

Under the subheading "Distribution and Habitat," the distribution of the species in North America and Missouri is described in relation to geographic areas and river drainages. Each species account is accompanied by a drainage map of Missouri on which each plotted symbol indicates a locality where the species has been collected. Solid black dots represent distribution records from collections made after 1970, and nearly all such records are supported by specimens I have examined. Hollow circles represent older distribution records obtained from published reports. Most of these are from a study by A.B. Williams.⁸⁹

The small inset map shows the native range of the species in North America. A few species, including the northern crayfish (*O. virilis*) and red swamp crayfish (*P. clarkii*) have been widely and successfully introduced outside of their native range, but no attempt was made to indicate these range extensions.

Unless otherwise credited, information in the section headed "Habits and Life History" is from field investigations conducted for this report. These observations were supplemented by information obtained from published reports. Studies made in Missouri or neighboring states were used as sources of supplemental information whenever possible. These sources of information are indicated in the text by small superscript numbers that refer to the numbered list of references in the back of the book. The studies cited do not represent an exhaustive list of published references on any species.

Collecting and Preserving

If crayfish are to be collected by methods or in numbers other than those sanctioned for bait collecting by the holder of a Missouri fishing permit, the collector must obtain a scientific collector's permit. Consult the "Wildlife Code of Missouri" for information regarding permits and restrictions on methods and limits.

Since crayfish occur in a wide variety of habitats and exhibit diverse habits, no single type of gear is effective for collecting them all. However, a 1/8-inch mesh seine 6 feet long and 4 feet deep, heavily weighted with lead on its lower edge and attached to brail poles, can be used to effectively sample a wide variety of habitats.

This seine can be set across the riffles of streams having current, and when the substrate upstream is disturbed by kicking or turning rocks by hand, the crayfish will be washed or will swim into the seine. In shallow, rocky areas having no current, the seine can be pulled through the water behind the collector as he walks backward, disturbing bottom materials with his feet as he goes. Heavy cover, such as beds of aquatic vegetation, undercut banks, or deposits of sticks and leaves can be surrounded and the crayfish driven into the seine from cover by kicking.

Ponds, sloughs and the pooled areas of streams with few obstructions can be drag seined. The collector pulls the seine rapidly through the water, being careful that the lead line hugs the bottom. The seine is pulled out onto a bank sloping gradually into the water, or is quickly lifted if a landing site is not available. A somewhat larger seine (at least 12 feet in length) of 1/4-inch mesh is more effective for drag seining than the one described for kick-seining.

A large dip net can be used effectively in much the same manner as a small seine to collect in riffles and around cover. It also can be used in waters clear enough for crayfish to be seen, by turning rocks and herding crayfish into the net with a stick or hand. In some situations, a face mask and snorkel are helpful for spotting crayfish. Since crayfish tend to be more active near dusk or at night, any technique that requires sighting the crayfish will be most effective at that time of day. Seines tend to be unwieldy in caves, and in such situations a short-handled dip net is more readily used. Head lamps are a preferred source of illumination in caves and at night because they leave the hands free to collect crayfish.

In thick growths of submergent vegetation and other situations where a seine or dip net are not effective, lift nets and various traps similar in design to minnow traps are effective. These can be baited with dog food, dead fish, or other materials attractive to crayfish. I have used a roller push net of the design described by K. Strawn⁸¹ for sampling in dense vegetation where seining would not be effective.

Burrowing crayfish can be collected by the laborious process of digging them out. However, since burrows not uncommonly are 4 feet or more in depth, this is not very practical. If the water table is close to the surface, the burrow can be enlarged until water is encountered, and if the water is agitated and the collector remains quiet, the crayfish often will come to the surface and occasionally will actually come out of the water. Typically, the presence of the crayfish is indicated by its antennae waving at the water's surface. If the collector is quick he can pin the crayfish against the side of the burrow and extricate it. On warm, rainy nights, burrowing crayfish can sometimes be observed and captured at the mouths of their burrows or

as they explore the surrounding area in search of food or mates. M.J. Norroky⁶³ has described an ingenious and effective trap that can be constructed easily from plastic pipe, sheet metal and wire. This trap can be positioned over the burrow to trap the crayfish as it attempts to leave its burrow.

Crayfish specimens can be preserved for study or as voucher specimens for locality records by placing them in a solution consisting of one part formalin and nine parts water. After three days to a week in this solution, the specimens should be soaked for three days in tap water (changing the water each day) and transferred for permanent storage to 70 percent ethyl alcohol or 40 percent isopropyl alcohol.

Canning jars in various sizes make adequate field containers for specimens. Containers should be large enough to receive the largest specimens without crowding or distortion. Each field container should have a label placed inside which lists the date, precise locality, field number and the names of the collectors. Labels should be of good bond paper and should be filled out with waterproof ink or pencil. The field number on the label will relate the collection to records kept in a field notebook.

The nature of these records will depend on the interests of the collector, but in addition to information on the field label, may include a physical description of crayfish habitats and their surroundings, an indication of collecting methods and effort, and tentative field identifications of species with notes on abundance, habitat, life colors, life history stages, behavior, etc.

Identification

A major deterrent to the study and appreciation of crayfish by the non-specialist is the difficulty in determining the species. Identification keys developed to identify preserved crayfish place heavy reliance on slight differences in structures (gonopods) found only in Form I males. Form II males, females and juveniles often cannot be identified using the keys alone.

Fortunately, as the reader can infer by studying the color plates of crayfish in this book, the various species often differ markedly in their life colors. Also, many species have def-

inite and quite limited distributions, so the number of species that must be considered in making an identification from any given area is quite limited. The reader is referred to the section of this book titled "Distribution and Habitat" (page 16) for a discussion of these regional differences in the crayfish fauna. A judicious use of the color plates and distributional information will suffice to provide at least a tentative identification for most crayfish specimens collected in Missouri.

In conducting general surveys of Missouri crayfish I have found that the following procedure greatly facilitates sorting and identification of the collections and I highly recommend it to others. As collecting proceeds, keep the specimens alive in buckets. When collecting is completed, sort the collection into as many crayfish types as are evident, based on differences in color and general morphology. I use the large trays sold by camera stores for darkroom use in sorting live crayfish, but any shallow containers of similar size will suffice. The different types of crayfish should be preserved separately if they are to be subsequently identified with conventional crayfish keys. They can be assigned a tentative field identification, so the collector can relate field notes on color patterns, habitat preferences, etc., to the various crayfish types in the collection. A field identification can be obtained by comparing the specimens with the color photographs in this book.

As an additional check on the identification, it is advisable to turn to the account for that species so the specimen can be checked for inconsistencies against the information provided in the "Description." Most of the characters can be seen with the unaided eye, but a hand lens will be helpful to examine the gonopods and other small structures. The information on distribution, including the distribution map, should be checked to determine if the collection site is within the range of the species. If the site is well outside of the known range of the species in Missouri, special care will be required to determine whether this results from a misidentification or range extension.

If the sorting is carefully done, the collector will find that virtually all of the crayfish of a given type will be of the same species when they are studied critically in the laboratory. For species that exhibit little color variation with

size or stage of maturity (i.e., most *Cambarus* and *Orconectes*) field sorting in the manner described makes possible a tentative identification of Form II males, females and juveniles by associating them with Form I males of the same species. For species in which the juveniles and adults differ considerably in color (i.e., most species of *Procambarus*), the juveniles of different species can generally be separated by field sorting. For example, juveniles of both the white river crayfish (*P. acutus*) and red swamp crayfish (*P. clarkii*) have a similar background color (light greenish-grey), but the former species generally has an overlying pattern of small dark spots while the latter has a pattern of dark vermiculations.

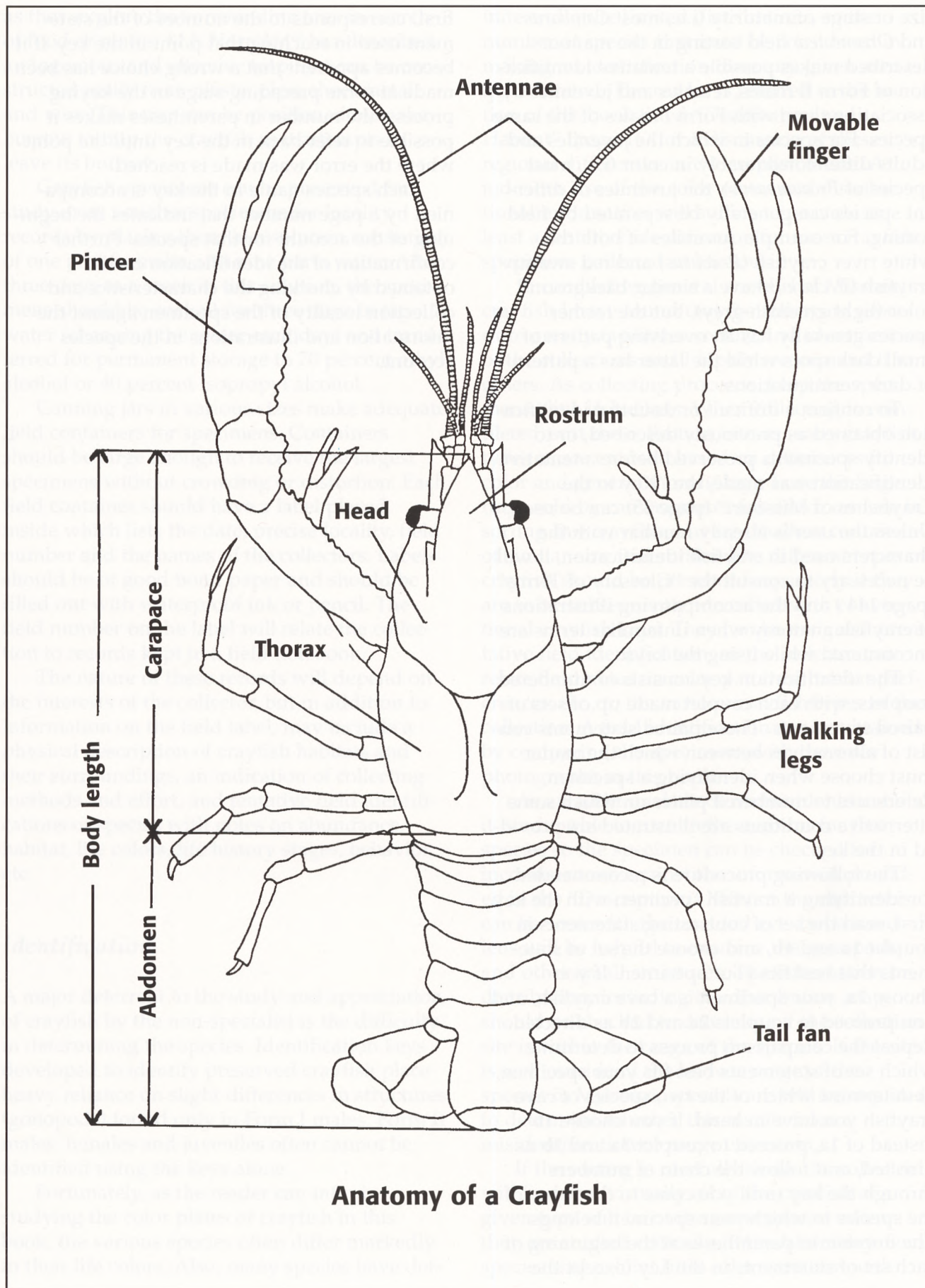
To confirm a difficult or doubtful identification obtained as previously described, or to identify specimens preserved before a tentative identification was made, the "Key to the Crayfishes of Missouri" (page 35) can be used. Unless the user is already familiar with the characters used in crayfish identification, it will be necessary to consult the "Glossary of Terms" (page 144) and the accompanying illustrations of crayfish anatomy when unfamiliar terms are encountered while using the keys.

The identification key consists of numbered couplets, with each couplet made up of sets of paired statements. These paired statements consist of alternatives between which the reader must choose when identifying a specimen. References to numbered plates on which some alternative conditions are illustrated are provided in the key.

The following procedure is recommended for identifying a crayfish specimen with the key. First, read the set of contrasting statements in couplet **1a** and **1b**, and choose the set of statements that best fits your specimen. If you choose **1a**, your specimen is a cave crayfish, and you proceed to couplets **2a** and **2b** as directed. Repeat the comparison process to determine which set of statements best fits your specimen, to determine which of the two species of cave crayfish you have in hand. If you choose **1b** instead of **1a**, proceed to couplet **3a** and **3b** as directed, and follow the chain of numbers through the key until you come to the name of the species to which your specimen belongs. The number in parentheses at the beginning of each set of statements in the key (except the

first) corresponds to the number of the statement used in reaching that point in the key. If it becomes apparent that a wrong choice has been made at some preceding stage in the keying process, the number in parentheses makes it possible to refer back in the key until the point where the error was made is reached.

Each species name in the key is accompanied by a page number that indicates the beginning of the account for that species. Further confirmation of the identification can be obtained by checking the characteristics and collection locality of the specimen against the information and illustrations in the species account.



Key to the Crayfishes of Missouri

All references to male crayfish are to Form I males.

- 1a. Eye inconspicuous and without pigment; body and appendages predominantly white, sometimes tinged with reddish brown. Illustrations: Plate 5H.
Cave crayfish
Go to2
- 1b. Eyes conspicuous and pigmented; body and appendages not predominantly white. Illustrations: Plate 1F.
Go to3
- 2a. (From 1a.) Areola broad, the grooves defining its margins well separated at midpoint of their length; acumen length nearly equal to basal width of rostrum; setae on pincers short and inconspicuous; primary (yellow) process of male gonopod with a notch near tip. Illustrations: Plate 5E,F,H.
Salem Cave Crayfish
Cambarus hubrichtiPage 56
- 2b. (From 1a.) Areola narrow, the grooves defining its margins nearly touching at midpoint of their length; acumen length much less than basal width of rostrum; setae on pincers long and conspicuous; primary (yellow) process of male gonopod without a distinct notch near tip. Illustrations: Plate 7E,F,H.
Bristly Cave Crayfish
Cambarus setosusPage 62
- 3a. (From 1b.) Areola absent or much reduced, the grooves defining its lateral margins touching at midpoint of their length. Illustrations: Plate 3F; Plate 31F.
Go to4
- 3b. (From 1b.) Areola well-developed, the grooves defining its lateral margins well separated for their entire lengths. Illustrations: Plate 4F; Plate 15F.
Go to9

- 4a. (From 3a.) Acumen short, not set off from rostrum by conspicuous spines; distance along dorsal midline from cervical groove to back of carapace going much less than 3.0 times into abdomen length; pincer broad, its dorsal surface with numerous pitlike depressions (punctae). Illustrations: Plate 3C,F.
Go to5
- 4b. (From 3a.) Acumen long, set off from rostrum by conspicuous spines; distance along dorsal midline from cervical groove to back of carapace going about 3.0 times into abdomen length; pincer not broad, its dorsal surface smooth or with numerous low bumps (tubercles). Illustrations: Plate 31C,F.
Go to7
- 5a. (From 4a.) Carapace length distinctly greater than abdomen length; male gonopod terminating in four short, nearly straight processes; female sperm receptacle with a deep anterior groove bordered by tuberculate ridges. Illustrations: Plate 32B,E.
Grassland Crayfish
Procambarus gracilisPage 136
- 5b. (From 4a.) Carapace length approximately equal to abdomen length; male gonopod terminating in two long, strongly curved processes; female sperm receptacle without a deep anterior groove bordered by tuberculate ridges. Illustrations: Plate 3B,D.
Go to6
- 6a. (From 5b.) Cervical groove not interrupted laterally; margin of eye socket with a well-defined bump posteriorly near lower edge of eye; moveable finger of pincer with only a shallow notch on inner margin near base and without a thick growth of hairlike setae along opposing margin of fixed finger. Illustrations: Plate 3A,C.

Devil Crayfish

Cambarus diogenes Page 51

- 6b. (From 5b.) Cervical groove interrupted laterally; margin of eye socket without a well-defined bump posteriorly near lower edge of eye; moveable finger of pincer with a deep notch on inner margin near base and with a thick growth of hairlike setae along opposing margin of fixed finger. Illustrations: Plate 8A,C.

Digger Crayfish

Fallicambarus fodiens Page 66

- 7a. (From 4b.) Acumen longer than remainder of rostrum; pincer very narrow, its width about equal to width of rostrum between eyes. Illustrations: Plate 14C,F.

Shrimp Crayfish

Orconectes lancifer Page 86

- 7b. (From 4b.) Acumen much shorter than remainder of rostrum; pincer moderately broad, its width much greater than width of rostrum between eyes. Illustrations: Plate 24C,F.

Go to 8

- 8a. (From 7b.) Rostrum with margins strongly converging, its width at rostral spines about half its width at base; carapace and dorsal surface of pincer with numerous small wartlike bumps, appearing granular; male gonopod terminating in more than two short, inconspicuous processes. Illustrations: Plate 31A,C,D,F.

Red Swamp Crayfish

Procambarus clarkii Page 133

- 8b. (From 7b.) Rostrum with margins slightly converging, its width at rostral spines much more than half its width at base; carapace and dorsal surface of pincer without small wartlike bumps, appearing smooth; male gonopod terminating in two long, conspicuous processes. Illustrations: Plate 24A,C,D,F.

Gray-speckled Crayfish

Orconectes palmeri Page 112

- 9a. (From 3b.) Acumen merging smoothly into lateral margins of rostrum, without spines; rostral surface between eyes nearly flat. Illustrations: Plate 9G.

Go to 10

- 9b. (From 3b.) Acumen set off from lateral margins of rostrum by well-developed spines (spines sometimes weakly developed or absent in two species); rostral surface between eyes concave (dished in) in most species, including those with spines weakly developed or absent. Illustrations: Plate 10F.

Go to 11

- 10a. (From 9a.) Areola broad, its width going less than 2.0 times into width of rostrum between eyes; primary processes of male gonopods very long, the right and left processes overlapping, like crossed sabers; body length not more than 2.0 inches. Illustrations: Plate 9C,G.

Shield Crayfish

Faxonella clypeata Page 72

- 10b. (From 9a.) Areola narrow, its width going much more than 2.0 times into width of rostrum between eyes; primary processes of male gonopods short, the right and left processes not overlapping; body length commonly more than 2.0 inches. Illustrations: Plate 33 G.

Vernal Crayfish

Procambarus viaeveridus Page 138

- 11a. (From 9b.) Rostral surface between eyes flat; males with hooks on bases of first and second pairs of walking legs; body length not more than 1.3 inches. Illustrations: Plate 2C,G.

Go to 12

- 11b. (From 9b.) Rostral surface between eyes concave (dished in); males never with hooks on bases of first pair of walking legs; body length commonly more than 1.3 inches. Illustrations: Plate 12C,G.

Go to 13

- 12a.** (From 11a.) Rostrum broader, its lateral margins slightly convex (rounded outward); male gonopod with terminal processes strongly curved; female with raised part of sperm receptacle symmetrically positioned on midline. Illustrations: Plate 1B,D,F.
Cajun Dwarf Crayfish
Cambarellus puer Page 43
- 12b.** (From 11a.) Rostrum narrower, its lateral margins nearly straight; male gonopod with terminal processes nearly straight; female with raised part of sperm receptacle positioned to one side of midline. Illustrations: Plate 2B,E,G.
Shufeldt's Dwarf Crayfish
Cambarellus shufeldtii Page 44
- 13a.** (From 11b.) Carapace height greater than carapace width; acumen of rostrum usually not set off from remainder of rostrum by distinct spines or tubercles; male gonopod terminating in four short, inconspicuous processes; life colors of adult typically a uniform dark burgundy-red with a black v-shaped stripe on abdomen. Illustrations: Plate 30 A,E,G.
White River Crayfish
Procambarus acutus Page 130
- 13b.** (From 11b.) Carapace height less than carapace width; acumen of rostrum usually set off from remainder of rostrum by distinct spines or processes; male gonopod terminating in two conspicuous processes; life colors of adult not a uniform dark burgundy-red. Illustrations: Plate 10 A,D,F.
Go to14
- 14a.** (From 13b.) Carapace broad and dorsally flattened, its height much less than its width at lateral margins of cervical groove; carapace length greater than abdominal length; primary (yellow) process of male gonopod broad and sickle-shaped. Illustrations: Plate 4A,D,F.
Go to15
- 14b.** (From 13b.) Carapace not broad and dorsally flattened, its height nearly equal to its width at lateral margins of cervical groove; carapace length less than or equal to abdominal length; primary (yellow) process of male gonopod not broad and sickle-shaped. Illustrations: Plate 10 A,D,F.
Go to16
- 15a.** (From 14a.) Body and pincers without conspicuous black spots; primary (yellow) process of male gonopod with a shallow notch near tip. Illustrations: Plate 4D.
Hubbs' Crayfish
Cambarus hubbsi Page 53
- 15b.** (From 14a.) Body and pincers with many conspicuous black spots; primary (yellow) process of male gonopod without a notch near tip. Illustrations: Plate 6D.
Freckled Crayfish
Cambarus maculatus Page 59
- 16a.** (From 14b.) Pincer long and narrow, its width going more than 3.0 times into its length; acumen of rostrum prominent, its length going less than 2.0 times into length of rest of rostrum. Illustrations: Plate 15C,F.
Longpincer Crayfish
Orconectes longidigitus Page 88
- 16b.** (From 14b.) Pincer not long and narrow, its width going less than 3.0 times into its length; acumen of rostrum less prominent, its length going more than 2.0 times into length of rest of rostrum. Illustrations: Plate 16D,G.
Go to17
- 17a.** (From 16b.) Male gonopod with primary (yellow) process short, its tip not reaching as far forward as bases of first pair of walking legs when abdomen is flexed (bent); length of primary process going more than 3.0 times into gonopod length. Illustrations: Plate 13F.
Go to18

- 17b. (From 16b.) Male gonopod with primary (yellow) process long, its tip reaching as far forward as bases of first pair of walking legs when abdomen is flexed (bent); length of primary process going less than 3.0 times into gonopod length. Illustrations: Plate 17E.
Go to23
- 18a. (From 17a.) Width of palm less than length of rostrum; areola width less than half the width of rostrum between eyes. Illustrations: Plate 13C,D,H.
Go to19
- 18b. (From 17a.) Width of palm greater than length of rostrum; areola width more than half the width of rostrum between eyes. Illustrations: Plate 11C,F.
Go to20
- 19a. (From 18a.) Anterior margin of antennal scale straight; rostrum without lateral spines or with spines weakly developed; female sperm receptacle with depression (fossa) far to one side of midline. Illustrations: Plate 13B,C,E,H.
Papershell Crayfish
Orconectes immunisPage 83
- 19b. (From 18a.) Anterior margin of antennal scale angled; rostrum always with well-developed spines; female sperm receptacle with depression (fossa) centrally located on midline. Illustrations: Plate 28B,C,G.
Northern Crayfish
Orconectes virilisPage 122
- 20a. (From 18b.) Male gonopod with both processes yellow and translucent (corneous); female sperm receptacle with posterior margin nearly straight. Illustrations: Plate 11B,D.
Belted Crayfish
Orconectes harrisoniPage 78
- 20b. (From 18b.) Male gonopod with one process white and opaque (noncorneous); female sperm receptacle with posterior margin rounded or angular. Illustrations: Plate 18B,E.
Go to21
- 21a. (From 20b.) Male gonopod with primary (yellow) process nearly straight; female sperm receptacle without a conspicuous tonguelike posterior extension. Illustrations: Plate 10B,D.
Coldwater Crayfish
Orconectes eupunctusPage 76
- 21b. (From 20b.) Male gonopod with primary (yellow) process distinctly curved; female sperm receptacle with a conspicuous tonguelike posterior extension. Illustrations: Plate 18B,E.
Go to22
- 22a. (From 21b.) Male gonopod with secondary (white) process curved near tip and separated from primary (yellow) process by a space; male with hooks only on bases of second pair of walking legs; female sperm receptacle with anterior rim separated into two raised knobs by a notch at midline. Illustrations: Plate 18B,C,E.
Mammoth Spring Crayfish
Orconectes marchandiPage 97
- 22b. (From 21b.) Male gonopod with secondary process nearly straight and not separated from primary (yellow) process by a space; male with hooks on bases of both second and third pairs of walking legs; female sperm receptacle with anterior rim low and continuous, without a notch at midline. Illustrations: Plate 27B,C,E.
St. Francis River Crayfish
Orconectes quadruncusPage 120
- 23a. (From 17b.) Male with hooks on bases of both second and third pairs of walking legs; male gonopod with secondary (white) process flared (broadened) near tip and deeply grooved on inner margin. Illustrations: Plate 25C,I.
Big Creek Crayfish
Orconectes peruncusPage 114

- 23b. (From 17b.) Male with hooks only on bases of second pair of walking legs (sometimes also on third pair in *O. hylas*); male gonopod with secondary (white) process not flared (broadened) near tip and not deeply grooved on inner margin. Illustrations: Plate 12C,I.
Go to24
- 24a. (From 23b.) Male gonopod with secondary (white) process curved in same direction as primary (yellow) process, the processes separated by a broad space. Illustrations: Plate 26B,F.
Go to25
- 24b. (From 23b.) Male gonopod with secondary (white) process nearly straight or curved towards primary (yellow) process, the processes only narrowly separate or touching near tip. Illustrations: Plate 16E; Plate 22D.
Go to27
- 25a. (From 24a.) Male gonopod with length of primary (yellow) process nearly half of total gonopod length; female sperm receptacle with posterior margin sharply angular. Illustrations: Plate 26B,D,F.
Spothanded Crayfish
Orconectes punctimanusPage 116
- 25b. (From 24a.) Male gonopod with length of primary (yellow) process much less than half of total gonopod length; female sperm receptacle with posterior margin rounded. Illustrations: Plate 28B,E.
Go to26
- 26a. (From 25b.) Antennal scale broadest anterior to its midlength; body length not exceeding 2.5 inches. Illustrations: Plate 20C.
Meek's Crayfish
Orconectes meekiPage 103
- 26b. (From 25b.) Antennal scale broadest at its midlength; body length often greater than 2.5 inches. Illustrations: Plate 28C.
Northern Crayfish
Orconectes virilisPage 122
- 27a. (From 24b.) Male with gonopod tip not reaching anterior to bases of first pair of walking legs when abdomen is flexed. Illustrations: Plate 16E.
Go to28
- 27b. (From 24b.) Male with gonopod tip reaching anterior to bases of first pair of walking legs when abdomen is flexed. Illustrations: Plate 17E.
Go to30
- 28a. (From 27a.) Troughlike central depression of rostrum with a low anterior ridge (carina); pincer with a conspicuous black or brown ring at tip of each finger. Illustrations: Plate 22F.
Ringed Crayfish
Orconectes neglectusPage 105
- 28b. (From 27a.) Troughlike central depression of rostrum usually without a low anterior ridge (carina); pincer without a conspicuous black or brown ring at tip of each finger, except in some populations of *O. luteus*. Illustrations: Plate 16G.
Go to29
- 29a. (From 28b.) Male gonopod with a definite shoulder on anterior surface near base of primary (yellow) process; body length commonly exceeding 2.0 inches. Illustrations: Plate 16E.
Golden Crayfish
Orconectes luteusPage 92
- 29b. (From 28b.) Male gonopod without a definite shoulder on anterior surface near base of primary (yellow) process; body length not exceeding 2.0 inches. Illustrations: Plate 29D.
Williams' Crayfish
Orconectes williamsiPage 126
- 30a. (From 27b.) Male gonopod with secondary (white) process about as thick as primary (yellow) process; female sperm receptacle with anterior rim thin and without a distinct notch. Illustrations: Plate 12B,E.

Woodland Crayfish

Orconectes hylasPage 80

30b. (From 27b.) Male gonopod with secondary (white) process not as thick as primary (yellow) process; female sperm receptacle with anterior rim thick, and with a distinct notch. Illustrations: Plate 19B,E.

Go to31

31a. (From 30b.) Male gonopod with only a slight shoulder on outer surface near base of primary (yellow) process. Illustrations: Plate 23D.

Ozark Crayfish

Orconectes ozarkaePage 109

31b. (From 30b.) Male gonopod with a prominent shoulder on outer surface near base of primary (yellow) process. Illustrations: Plate 17E.

Go to32

32a. (From 31b.) Troughlike central depression of rostrum without a low anterior ridge (carina); spines or tubercles that set off acumen from rostrum strongly developed; antennal scale with inner margin not evenly rounded (angular); male with length of primary (yellow) process less than half of total gonopod length. Illustrations: Plate 17C,E,G.

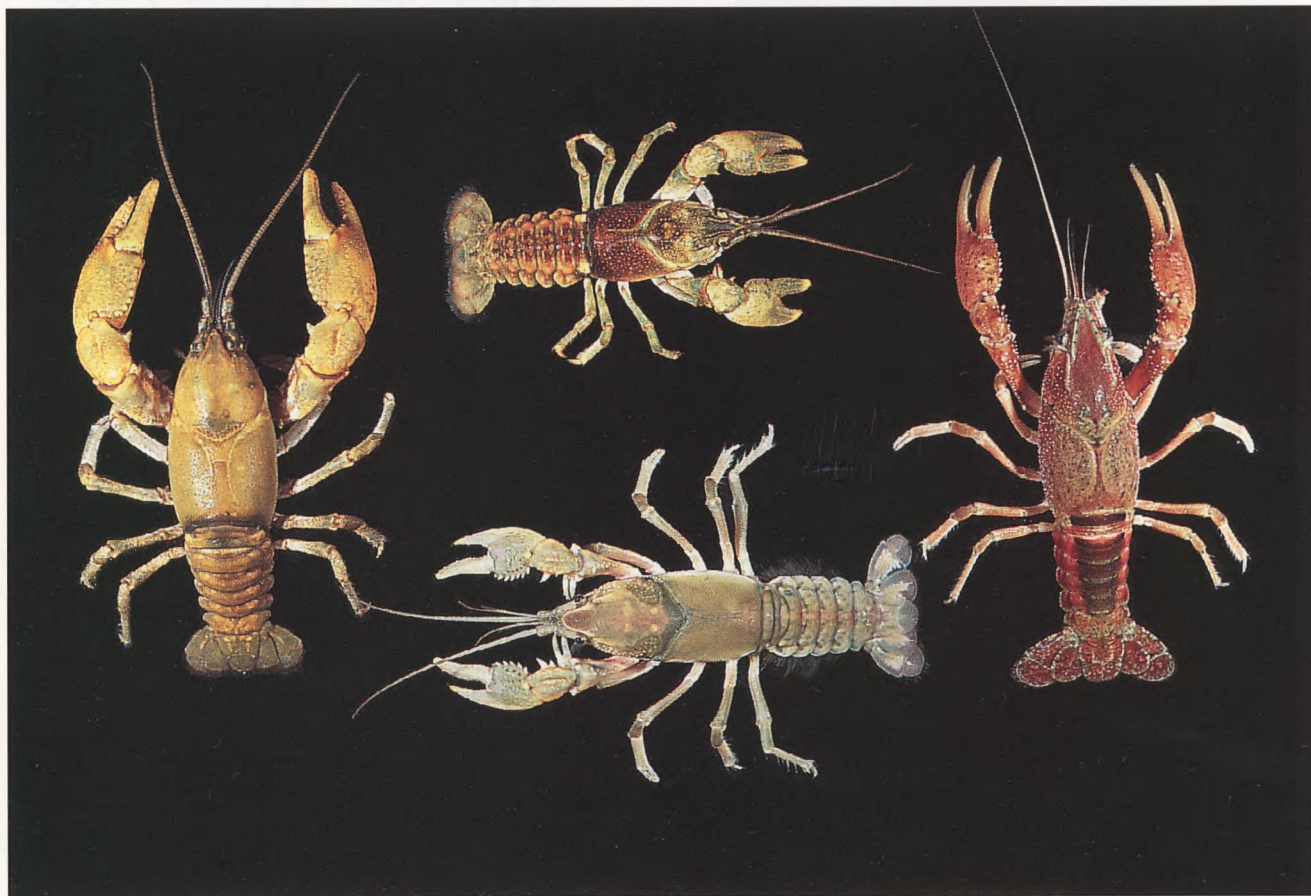
Neosho Midget Crayfish

Orconectes macrusPage 95

32b. (From 31b.) Troughlike central depression of rostrum usually with a low anterior ridge (carina); spines or tubercles that set off acumen from rostrum weakly developed or absent; antennal scale with inner margin evenly rounded; male with length of primary (yellow) process equal to or greater than half of total gonopod length. Illustrations: Plate 19C,E,G.

Saddlebacked Crayfish

Orconectes mediusPage 100



(Left) Hubbs' crayfish, *Cambarus hubbsi*; (top) coldwater crayfish, *Orconectes eupunctus*; (bottom) grassland crayfish, *Procambarus gracilis*; and (right) white river crayfish, *Procambarus acutus*.

Accounts of the Species



Cambarellus Ortmann **Dwarf Crayfishes**

As their name implies, crayfish of the genus *Cambarellus* are small; none achieve a body length much greater than an inch. These are essentially lowland species, and occur in swamps, sloughs and roadside ditches in the southern United States and Mexico.

Two of the 17 known species occur in Missouri. They differ most notably from other Missouri crayfish in their size. No specimens longer than 1.3 inches have been found in our collections.

In the field, dwarf crayfish can be distinguished from the young of other crayfish species by the dark lengthwise stripes or row of spots along the dorsal body surface, and a dark central blotch in the tail fan. The presence in a collection of females with eggs and Form I males, both less than 1.5 inches long, is a good indication that these individuals are *Cambarellus*.

In male *Cambarellus* the gonopod has three terminal processes, and hooks are present on the bases of the first and second pairs of walking legs. Males of other Missouri crayfish have two or four gonopod processes and never have hooks on the bases of the first pair of walking legs. The scientific name *Cambarellus* is Latin, meaning "small crustacean."

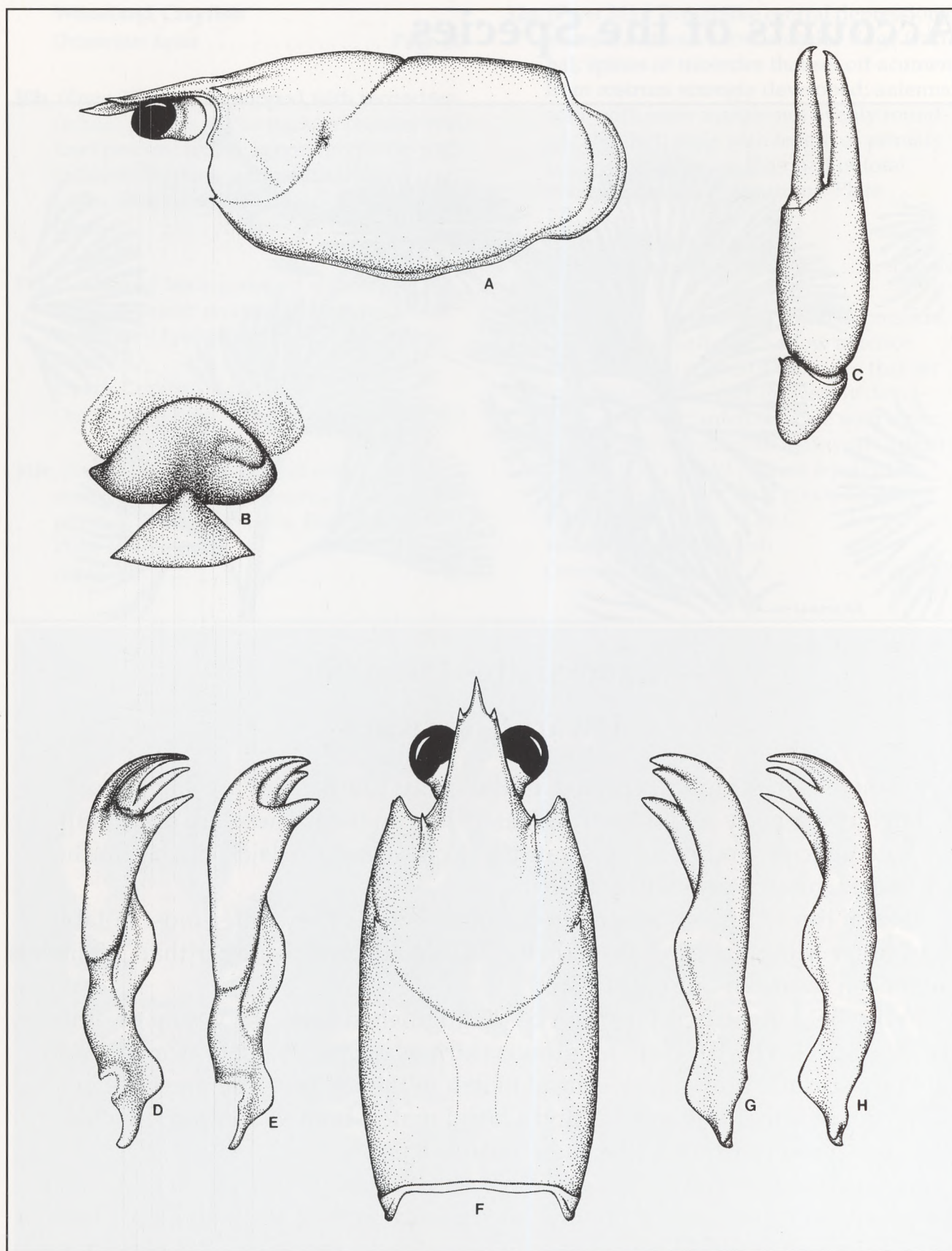
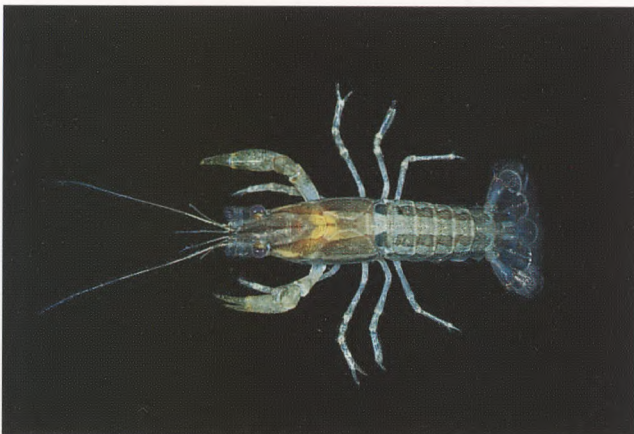


Plate 1. *Cambarellus puer*. A, lateral view of carapace; B, sperm receptacle of female; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

Cajun Dwarf Crayfish

Cambarellus puer Hobbs



Roadside pool, Scott County

Description

Characters: A small, brownish crayfish with slender pincers and lengthwise stripes or rows of spots along the body. Areola present. The surface of the rostrum is flat, without the central troughlike depression found in many crayfish species. The pincers are long, narrow and smooth, without conspicuous bumps or tubercles. In males, the gonopod has three terminal processes that are strongly curved. In females, the sperm receptacle lacks a fossa and its raised portion is symmetrical.

Life Colors: Background coloration reddish-brown to gray with conspicuous blue-black stripes or dashed lines running lengthwise along the carapace and abdomen. There is usually a conspicuous dark blotch in the central part of the tail fan. The pincers are not tipped with orange as in some other species.

Two distinct color phases, a striped phase and a spotted phase, occur in this species and in *C. shufeldtii*. See the account of *C. shufeldtii* for a discussion of this phenomenon.

Size: Adults are 0.7 to 1.3 inches in length, with females averaging slightly larger than males.

Scientific Name: *puer*, Latin, meaning "male child," perhaps in reference to the small size of mature males.

Most Like: Shufeldt's dwarf crayfish (*C. shufeldtii*) and the young of other species.

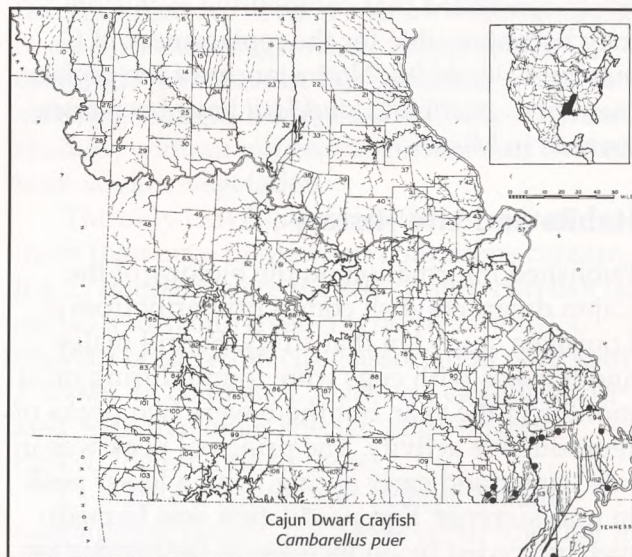
Differs: Distinguished from *C. shufeldtii* by the

strongly curved terminal processes on the male gonopod; processes nearly straight in *C. shufeldtii*. Also, the raised portion of the female sperm receptacle is symmetrical, not asymmetrical as in *C. shufeldtii*. The rostrum in *C. puer* is broader and its lateral margins are slightly convex, not nearly straight as in *C. shufeldtii*.

Distribution and Habitat

The Cajun dwarf crayfish occurs from southern Missouri and Illinois southward along the Mississippi River to Louisiana and westward to eastern Texas and extreme southeastern Oklahoma. In Missouri it has been collected from 12 localities, all in or immediately adjacent to the Lowland Faunal Region. This species appears to avoid the central, more intensively ditched and drained part of the lowlands. Perhaps it was more abundant and widely distributed in that region in presettlement times when shallow, standing-water habitats were more extensive.

In a Louisiana study, this species occurred most frequently in roadside ditches, ponds and cypress swamps, with some occurrences in slow-flowing bayous and creeks. These habitats were characterized by mud bottoms, luxuriant growths of aquatic vegetation, and water that



was clear, permanent, exposed to sunlight and less than 15 inches deep.⁷⁰ In a Louisiana ditch with steeply sloping banks and a maximum depth of 10 feet, *C. puer* was never collected farther than 2 feet from shore, nor from depths greater than 6 inches. This ditch was quite sta-

ble, with maximum fluctuations of less than 1 foot. Observations on the habitat of this species in Missouri are in general agreement with those in Louisiana, except that many Missouri habitats were subject to widely fluctuating water levels or were entirely dry from midsummer to early fall.

Crayfish species most closely associated with *C. puer* in Missouri, in descending order of association, were white river crayfish (*P. acutus*), shield crayfish (*F. clypeata*), vernal crayfish (*P. viaeveridus*), digger crayfish (*F. fodiens*) and red swamp crayfish (*P. clarkii*). All of these species burrow for at least part of their life cycle.

In Louisiana and Illinois, *C. puer* and *C. shufeldtii* were rarely found in the same body of water.^{65,70} In Missouri, *Cambarellus* occurred in 29 collections and in only one were both species found. This was a silty, disturbed habitat only sparsely populated with any crayfish, and the joint occurrence of the two *Cambarellus* species may have been temporary.

In Louisiana, *C. shufeldtii* appears to be extending its range at the expense of *C. puer*, since sites formerly inhabited by the latter species now yield only *C. shufeldtii*.⁷¹ Researchers found that under experimental conditions, *C. shufeldtii* was dominant over *C. puer* in most aggressive encounters and they tentatively concluded that competitive exclusion may be responsible for the replacement of *C. puer* by *C. shufeldtii*. No instances of the replacement of *C. puer* by *C. shufeldtii* have been documented in Missouri.

Habits and Life History

Published information on the biology of the Cajun dwarf crayfish comes primarily from a Louisiana study.³ In that study, Form I males and females with eggs were found during most months of the year, but there were two peaks of reproductive activity. The principal peak was in late winter and early spring, with a lesser peak in mid-summer. Egg production was immediately preceded by an increase in the proportion of Form I males in the population, suggesting that breeding occurred shortly before spawning. Males required 13 or 14 molts to achieve maturity. Some matured during the first breeding season following the one in which they were hatched. However, most did not mature until the second breeding season after hatching,

when they were about 1 year old. Males lived nearly 1.5 years unless removed from the population by predation or other factors.

In Missouri, *C. puer* was collected only from January to May. Form I males made up 93 percent of the males in the collections, but Form II males predominated in a small collection made in late May. Females carrying eggs occurred on seven separate dates between Feb. 26 and May 12. Females carrying eggs or young were found in Illinois from March to May.⁶⁵ In 14 Missouri egg-bearing females ranging in length from 1.0 to 1.3 inches, the number of eggs per female varied from 43 to 110, averaging 79. These eggs were about 1 mm. in diameter.

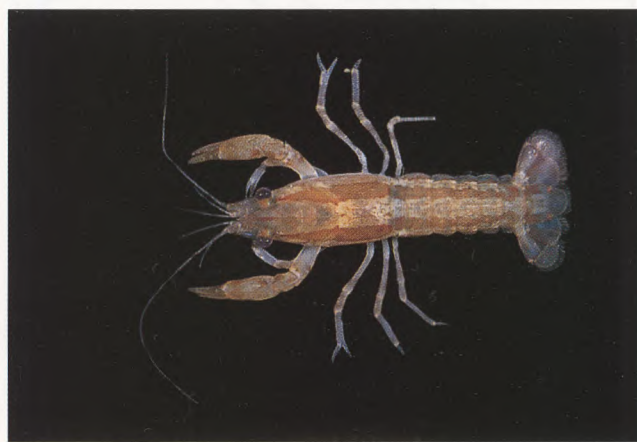
In the combined collections males predominated over females, representing 69 percent of the 363 specimens.

Importance

Dwarf crayfish are probably eaten by fish, turtles, wading birds and other vertebrates that share their habitat. Because of their small size, they are not generally used by humans as food or bait.

Shufeldt's Dwarf Crayfish

Cambarellus shufeldtii (Faxon)



Prairie Slough, Lincoln County

Description

Characters: A small, brownish crayfish with slender pincers and lengthwise stripes or rows of spots along the body. Areola present. The surface of the rostrum is flat, without the cen-

tral troughlike depression found in many species. The pincers are long, narrow and smooth, without conspicuous bumps or tubercles. In males the gonopod has three terminal processes that are nearly straight. In females the sperm receptacle lacks a fossa, and its raised portion is asymmetrical.

Life Colors: Very similar to *C. puer*. Like that species, two distinct color phases occur, a striped phase and a spotted phase.^{43,70} In the spotted phase, spots are arranged in lengthwise rows along the carapace and abdomen. In the striped phase these spots are fused into uninterrupted bands. These color phases occur in both sexes and no anatomical differences are associated with either phase. This dimorphism has been studied extensively by E.P. Volpe and G.H. Penn,⁸⁵ and they concluded that the color difference was due to a single gene, with the striped condition dominant over the spotted condition. These differences are adaptively neutral, and mating between the two color phases appears to be random.

Size: Form I males are 0.6 to 1.2 inches in length. Females typically are larger than males and achieve a maximum length of about 1.3 inches.

Scientific Name: *shufeldtii*, named in honor of R. W. Shufeldt.

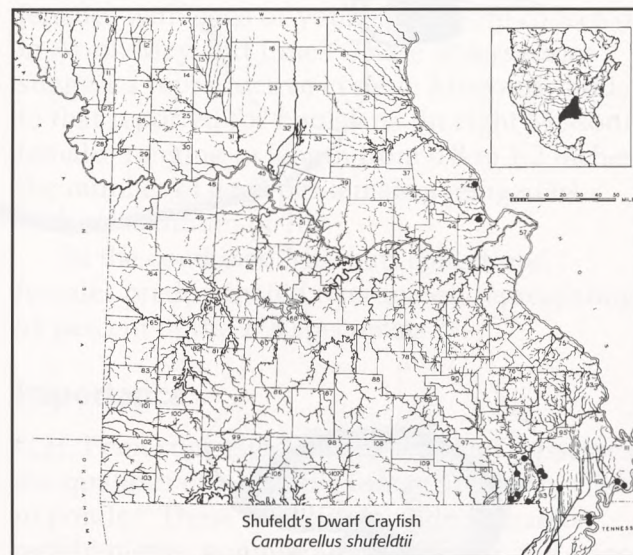
Most Like: *C. puer* and the young of other species.

Differs: Distinguished from *C. puer* by the nearly straight terminal processes on the male gonopod; processes strongly curved in *C. puer*. Also, the raised portion of the female sperm receptacle is asymmetrical, not symmetrical as in *C. puer*. The rostrum in *C. shufeldtii* is narrower and its lateral margins are nearly straight, not slightly convex as in *C. puer*.

Distribution and Habitat

Shufeldt's dwarf crayfish occurs along the Gulf Coast from southcentral Texas eastward to southwestern Alabama and northward in lowlands along the Mississippi River to Lincoln County, Missouri. In Missouri this species has been collected from 12 localities in the Lowland Faunal Region and two localities on the

Mississippi River flood plain above the mouth of the Missouri River. In the lowlands, distribu-



tion records are clustered along the lower Black, St. Francis and Mississippi rivers. Populations along the upper Mississippi River in St. Charles and Lincoln counties appear to be disjunct from those in the lowlands.

In the Reelfoot Lake area of Tennessee *C. shufeldtii* was found among decaying leaves and twigs in protected waters less than 6 inches deep along the edges of sloughs. Rooted and floating plants of several species were common in areas of the slough where this crayfish occurred.⁴³ In Missouri this species is found in swamps, sloughs and roadside ditches that are shallow, without noticeable current and choked with aquatic vegetation.

The only crayfish species that occurred more than once in Missouri collections containing *C. shufeldtii* were the red swamp crayfish (*P. clarkii*) and white river crayfish (*P. acutus*). *C. shufeldtii* occurred in close association only with *P. clarkii*. In contrast, *C. puer* was closely associated with five other species, and *P. clarkii* ranked lowest among these.

C. shufeldtii and *C. puer* occupy broadly overlapping ranges, but rarely occur together in Missouri or elsewhere (see account of *C. puer* for a discussion of this phenomenon).

Habits and Life History

The biology of *Cambarellus shufeldtii* has been studied intensively in Louisiana,^{68,70,54,55,3} and the

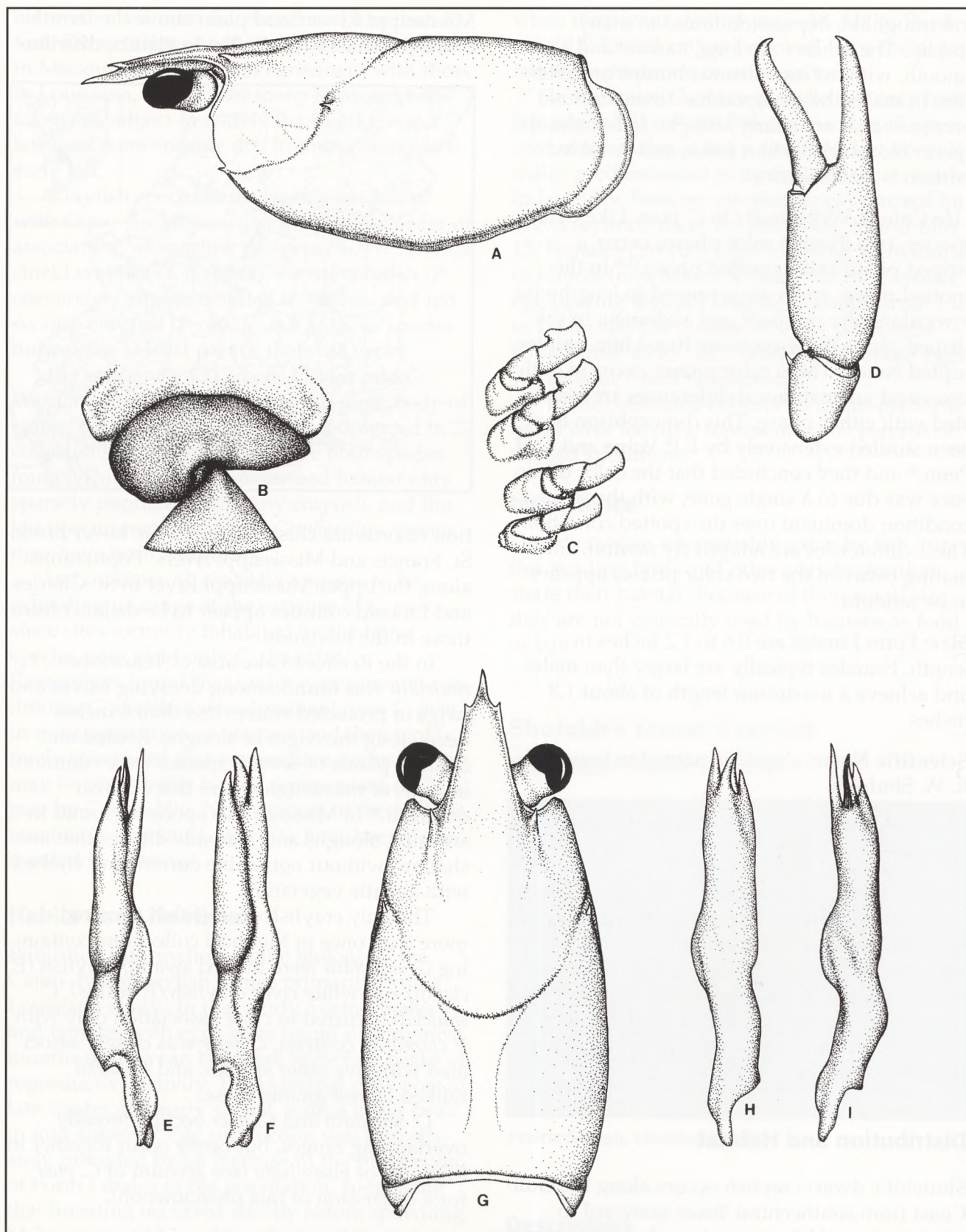


Plate 2. - *Cambarellus shufeldtii*. A, lateral view of carapace; B, sperm receptacle of female; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

following information is abstracted from those studies. This species is not a burrower, but survives dry seasons in "cells" having no surface connections, hollowing these out in the mud as water levels recede. The reproductive cycle of Shufeldt's dwarf crayfish is much like that of the Cajun dwarf crayfish, but spawning is less seasonal in occurrence. However, there is a peak in reproduction in late winter and early spring and a lesser peak in midsummer.

Females mature at a length of about 0.7 inches and may produce two broods during their life span of about one year. Females produce an average of 34 eggs per brood. The eggs are carried beneath the tail where the young remain attached until the second molt. The total time of attachment is about three weeks.⁵⁵ Males also may breed twice by the time they are 1 year old, but may live 15 to 18 months. Males undergo 12 to 13 molts before maturity, and may mature and breed during the first breeding season after the one in which they were spawned.

C. shufeldtii was less seasonal in my collections than *C. puer*, occurring in midsummer and autumn collections as well as late winter and early spring. Form I males predominated in col-

lections made in February, July, October and November. Females with eggs were collected during February, March and July. In Illinois, females with eggs or young also were collected in April, May and June.⁶⁵ These observations suggest a reproductive cycle in Missouri similar to that reported for Louisiana. In eight Missouri females ranging in length from 0.8 to 1.2 inches, the number of eggs per female averaged 64, with a maximum of 109.

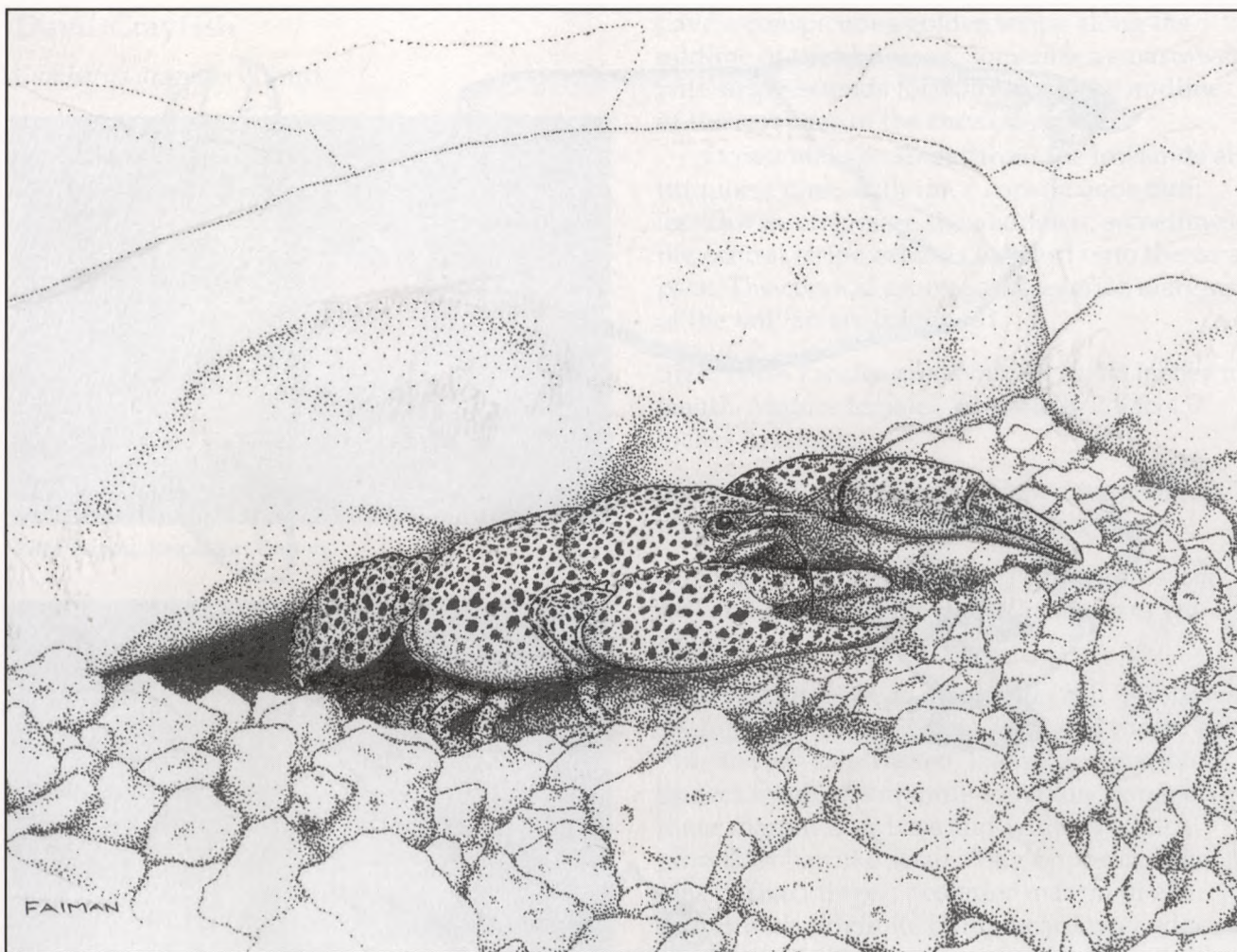
In the combined Missouri collections, females predominated over males, representing 54 percent of the 278 specimens.

Importance

G.H. Penn suggested that *C. shufeldtii* possesses the qualities of a suitable forage species for fish in ponds.⁶⁸ These qualities include its habitat requirements, nonmigratory behavior and vegetarian food habits. It does not burrow, roil the water, or decimate aquatic vegetation. It is small enough to be fed on by fingerling bass and sunfish. To my knowledge, the value of this species or *C. puer* as forage has not been studied in Missouri or elsewhere.



The devil crayfish, *Cambarus diogenes*, female carrying young; Ditch No. 1, Dunklin County



Cambarus Erichson

The genus *Cambarus* includes more than 60 known species, most of which occur in mountainous regions east of the Mississippi River. A secondary center of occurrence is in the Ozark Region of Missouri, Arkansas and Oklahoma where eight species are known. Five species of *Cambarus* occur in Missouri. These include the wide-ranging burrowing species, *C. diogenes*; two stream species, *C. hubbsi* and *C. maculatus*; and two species that are adapted to subterranean waters, *C. hubrichti* and *C. setosus*. All Missouri species except *C. diogenes* are restricted in distribution to the Ozark Faunal Region.

With the exception of the subterranean species, the Missouri *Cambarus* may be characterized as powerfully-built species with broad, dorsally flattened carapaces and large, heavy pincers. The subterranean species are more fragile in appearance, unpigmented and without functional eyes. The gonopods in male *Cambarus* have two terminal processes, both forming a right-angle to the main axis of the gonopod. The principal process is large and bladelike in appearance, while the secondary process is conical.

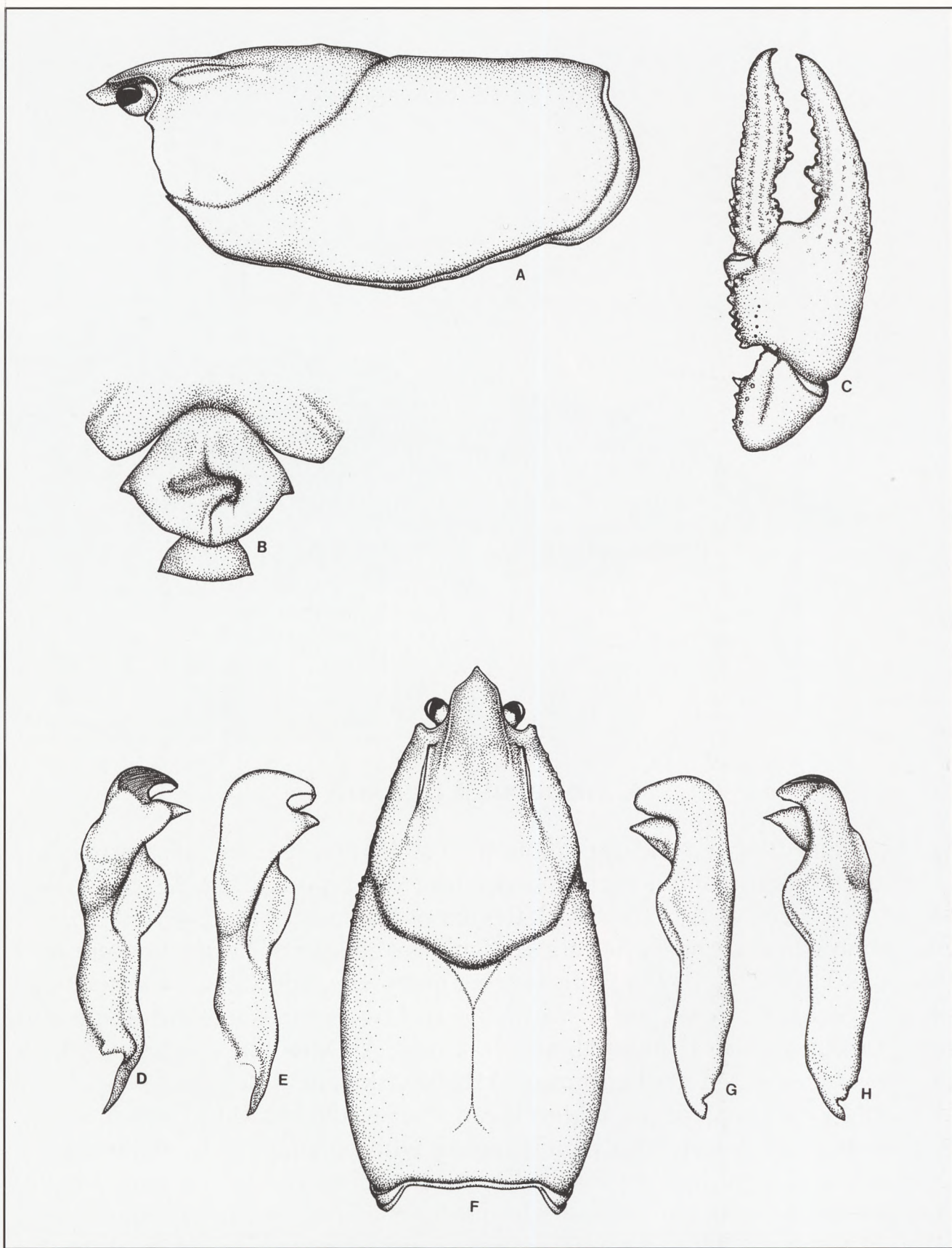
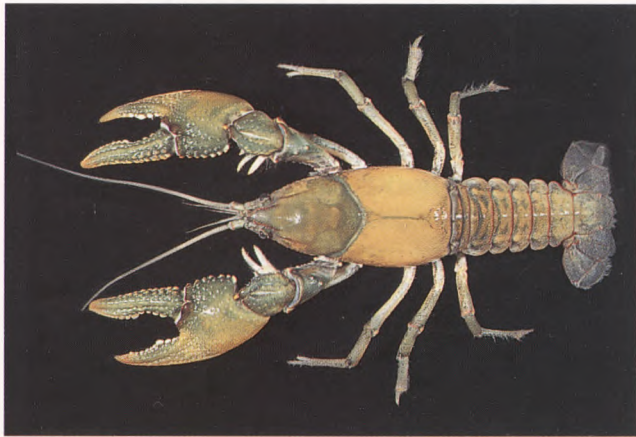


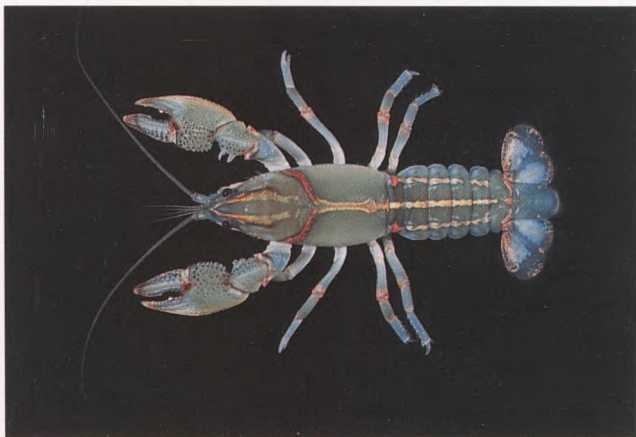
Plate 3. - *Cambarus diogenes*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

Devil Crayfish

Cambarus diogenes Girard



Wolf Bayou, Pemiscott County



Unnamed ditch, Stoddard County

Description

Characters: A powerfully built olive-tan crayfish with large, broad pincers. Carapace approximately equal in length to abdomen. Areola absent. Rostrum broad, with a central trough-like depression and a short acumen that lacks lateral spines or tubercles. In males, the gonopod has two terminal processes that are at right angles to the main gonopod axis and the primary (central) process is strongly curved, short and bladelike.

Life Colors: Typically, the devil crayfish is a nearly uniform olive-drab or tan without conspicuous markings except for orange or red tips on the pincers and often orange-red margins on the rostrum, abdominal segments and tail fan.

Many specimens from the Prairie Region

have a conspicuous golden stripe along the midline of the abdomen; sometimes a narrower pale stripe extends forward along the midline of the carapace to the cervical groove.

Occasional specimens from the lowlands are turquoise-blue, with three conspicuous buff, lengthwise stripes on the abdomen; sometimes the central stripe extends forward onto the carapace. The cervical groove and anterior margins of the tail fan are bright red.

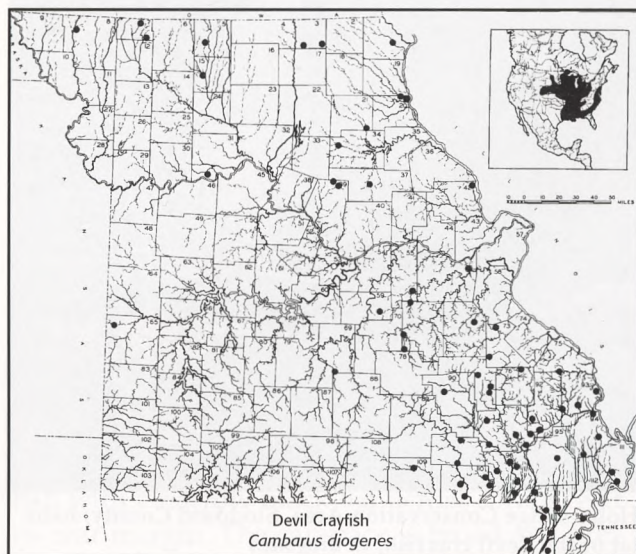
Size: Form I males are about 3.1 to 4.8 inches in length. Mature females are usually 2.8 to 4.0 inches in length.

Scientific Name: *diogenes*, named for a Greek philosopher said to have lived in a tub.

Most Like: Digger crayfish (*Fallicambarus fodiens*) and grassland crayfish (*Procambarus gracilis*).

Differs: Differs from digger crayfish as follows: cervical groove separating head and thorax continuous, not interrupted, laterally; moveable finger of pincer with only a shallow notch on inner margin near base and without a thick growth of hairlike setae along opposing margins of fixed finger; posterior margin of eye socket with a definite bump near lower edge of eye; fossa of female sperm receptacle centrally located on midline and bordered anteriorly by a definite ridge.

Differs from grassland crayfish as follows: carapace length nearly equal to abdominal length, not distinctly shorter; male gonopod with two, not four, terminal processes that are



strongly curved; anterior ridge of the female sperm receptacle not interrupted by a definite groove.

Distribution and Habitat

This wide-ranging crayfish occurs throughout much of the eastern United States east of a line from eastern Texas to central Minnesota, except for the Florida peninsula and much of the Appalachians, and westward along the Missouri and Platte rivers to southern North Dakota, eastern Wyoming and Colorado. In Missouri it is nearly statewide in distribution but apparently is absent from the southwestern Ozarks (White and Neosho drainages). Since this burrowing species spends much of its life underground it is difficult to collect and is undoubtedly more generally distributed than my records suggest, particularly in north and west Missouri.

The devil crayfish typically occurs in burrows that it constructs in timbered and formerly

timbered areas along streams and ditches. Females bearing eggs and young, and to a lesser extent males, are often found in both temporary and permanent surface waters in late winter and spring. After dispersing from the female, the young remain in open waters until they begin to burrow.

Because of its burrowing habit, *C. diogenes* does not occur in close association with any other species of crayfish. No species occurred at more than two of the 36 localities where the devil crayfish was recorded.

Habits and Life History

Though the devil crayfish is one of the most widely distributed and successful crayfish species in North America, no comprehensive study of its biology has been published. However, good summaries of the scattered and fragmentary literature, with additional regional notes, are available.^{90,65,46} The burrowing habits of this species also have been described in detail.^{28,83,31,29,30}

The burrows of the devil crayfish are most often found along the banks of streams, but also occur in other low, swampy areas. Sometimes the burrow consists of a single vertical shaft extending to groundwater, occasionally to a depth of 15 feet. More often there are two or more entrance tunnels that converge diagonally on a vertical shaft. If the burrow is close to a stream, a horizontal passage usually extends from the vertical shaft, opening into the stream beneath its surface. There is a flask-shaped enlargement at the bottom of the burrow and additional such enlargements may occur along its length, each presumably marking the bottom of the burrow at earlier stages in its development.

The burrow is often topped by a mud chimney consisting of material brought to the surface as the burrow is constructed. This chimney may be 12 inches high, but is often much less. Whether the chimney is a by-product of burrowing, or is constructed by design, is a matter of debate. If the latter view is correct, its functional significance is obscure. To me it seems likely that the chimney is constructed by design, representing the most efficient way of disposing of material that is a by-product of excavation, while minimizing exposure of the



Holly Ridge Conservation Area, Stoddard County; habitat of the devil crayfish, *C. diogenes*

burrow's occupant to predation.

Water may fill the burrow almost to its mouth or may be several feet beneath the ground, its level fluctuating with rainfall patterns. The oxygen content of burrow water sometimes is scarcely sufficient to support life and the crayfish is reported to spend much of its time at the air-water interface where its gills are exposed to air for respiration while being kept moist by the high humidity environment of the burrow.^{31,46} That burrow water is not always nearly devoid of oxygen is suggested by the report of more than 6,000 ostracods, copepods, and amphipods in a quart of water from a burrow along Missouri's Current River.¹⁴ This observer suggested that crayfish burrows may serve as refuges for small invertebrates in temporary ponds during dry seasons.

The food and feeding habits of the devil crayfish are unknown but the general assumption is that it emerges from its burrow at night to feed on terrestrial vegetation and other organic matter. Burrowing crayfish are sometimes found wandering at considerable distances from any burrow, particularly on warm, rainy nights in spring. During dry seasons the crayfish probably remain in their burrows for extended periods. At such times the entrances to burrows are often sealed with mud which may help maintain high humidity in the burrow and keep out snakes and other potential predators.

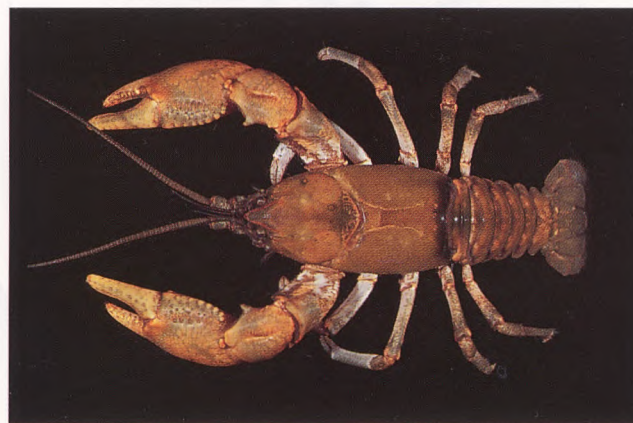
The essential features of the annual cycle of the devil crayfish, pieced together from published references and personal observations, are these.

After a general fall molt by mature males from Form II to Form I, mating occurs in the burrows or in open water. At the latitude of Missouri, mating has been observed in October⁹⁰ and may continue into late winter or early spring.⁶⁵ The latter study found females with eggs in Illinois as early as January. I have observed females with eggs and with young in southeast Missouri in late March. In late winter and spring, adults — predominantly females bearing eggs or young — are commonly found in surface waters, particularly waters that are temporary and devoid of fish. Large numbers of young are found in these waters in May, indicating that by this time they are dispersing from the females.

Incubation and early development of the young presumably occurs in the burrows as well as in surface waters. According to published references, the young begin burrowing by mid-summer when they are about 0.75 inches long. However, I have found substantial numbers of young 0.8 to 1.75 inches long still in surface waters in August and October. Most males are in Form II by late spring and adult females may also undergo a general molt at this time. Most adults are in burrows and inactive during the extended warm, dry periods that characterize Missouri summers.

Hubbs' Crayfish

Cambarus hubbsi Creaser



Spring River, Oregon County



James River, Christian County

Description

Characters: A powerfully built, olive-tan crayfish with a narrow black bar across carapace at its rear margin. The carapace is broad and dor-

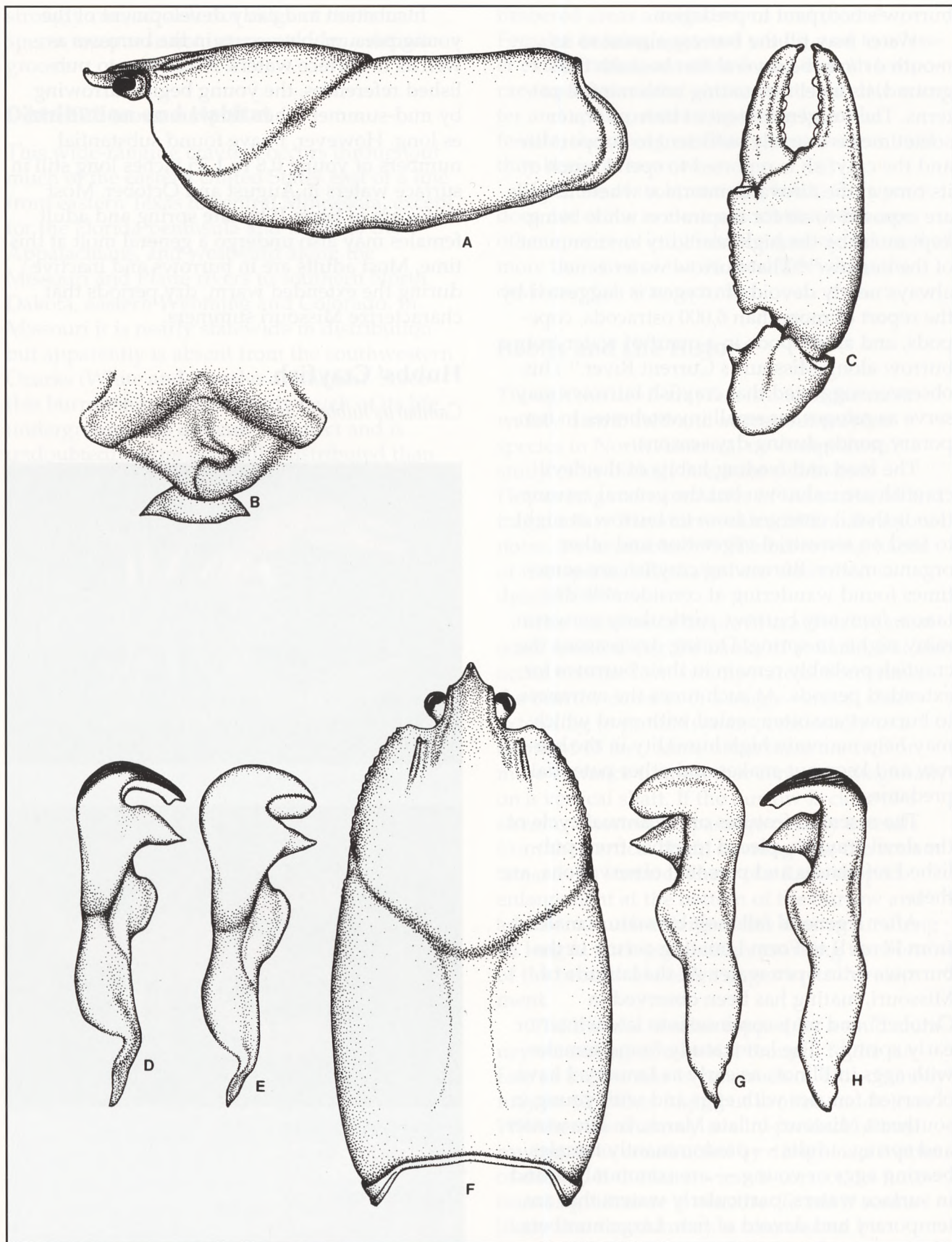


Plate 4. - *Cambarus hubbsi*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

sally flattened, its length greater than length of abdomen. Areola present. Rostrum with a well-developed, central troughlike depression, its lateral margins taper gradually into base of short acumen. Acumen with weakly developed tubercles at base and tip. In males the gonopod has two terminal processes that are at right angles to the main gonopod axis and the primary (central) process is strongly curved and bladelike.

Life Colors: Typically, this crayfish is a nearly uniform olive-tan or reddish-tan except for a prominent black saddle mark of nearly uniform width across rear margin of carapace. Abdomen often more reddish than carapace.

Specimens from the upper White River drainage (James River and Beaver Creek) are bright orange-red.

Size: Adults are usually 1.4 to 2.5 inches in length. The largest specimen in my collections, a female, is 3.5 inches in length.

Scientific Name: *hubbsi*, named for Carl Hubbs, a prominent ichthyologist.

Most Like: Freckled crayfish (*Cambarus maculatus*).

Differs: Differs from freckled crayfish most notably in nearly uniform color pattern, the only conspicuous mark being a narrow black saddle mark across rear margin of carapace. In Form I males the principal (central) process of gonopod has a shallow notch near its tip and there are usually 4 to 8 tubercles along inner margin of palm.

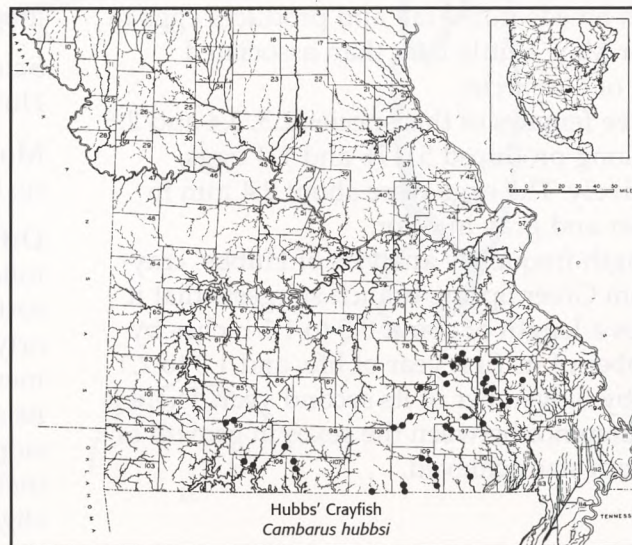
Distribution and Habitat

Hubbs' crayfish has a limited range in the Ozarks of southern Missouri and northern Arkansas. In Missouri it occurs commonly in all principal drainages on the southern slope of the Ozark Uplands, from the St. Francis River west to Eleven Point River and adjacent Spring River. It has been collected in James River, Beaver Creek and Little North Fork of the White River system, but is rare.

This species inhabits permanent-flowing, clear, high-gradient, rocky streams, ranging in size from small creeks to moderate-sized rivers.

The largest population I encountered was in Greer Spring branch, third largest spring in the Ozarks, and in the Eleven Point River downstream from Greer Spring. It is nearly always collected from beneath large rubble and boulders that are well-seated in sand and gravel.

Eleven other species of crayfish occurred in



collections that included Hubbs' crayfish, but the species most closely associated with it were the coldwater crayfish (*O. eupunctus*, Ozark crayfish (*O. ozarkae*), Mammoth Spring crayfish (*O. marchandi*) and woodland crayfish (*O. hylas*).

Habits and Life History

Hubbs' crayfish excavates tunnels beneath rubble and boulders from which it presumably emerges at night to forage over the stream bottom. I have never seen this species in the open except when disturbed. It is not a quick or agile swimmer and seldom takes evasive action when attempts are made to capture it by hand.

Form I males of Hubbs' crayfish were collected in all seasons of the year but most males were in the Form II stage from May to September. Form I males predominated in my collections in late October and November and also in March and May. There is probably a general molt by males from Form II into Form I in late September. Males remain in the Form I stage through winter and early spring, molting back to Form II in May.

Mating has not been observed in this species. A female Hubbs' crayfish with eggs

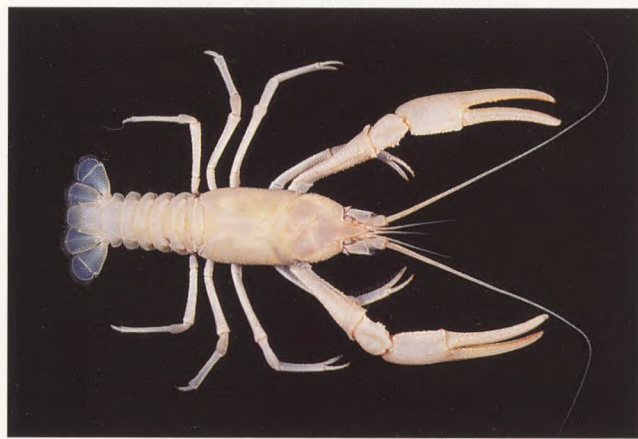
was collected in Otter Creek, Reynolds County, on May 6, 1986. Females collected in late March 1988 and mid-April 1990 did not have eggs, even though females of four species of *Orconectes* collected with them had eggs. However, two of five female Hubbs' crayfish collected March 22 to 24, 1988 produced eggs in the laboratory April 1, 1988. Probably, Hubbs' crayfish breeds in the fall and produces eggs in April or May, a little later than associated species of *Orconectes*.

Three females of this species 2.3, 2.4 and 2.6 inches long produced 51, 76 and 111 eggs, respectively. The eggs were about 2.4 mm in diameter and gray in color.

Length-frequency analysis of Hubbs' crayfish from Greer Spring branch suggests that it achieves a length of about 0.5 to 1.1 inches by November of its first year of life, and 1.3 to 2.1 inches by November of its second year. There is little difference between the sexes in growth or maximum size achieved.

Salem Cave Crayfish

Cambarus hubrichti Hobbs



Fisher (Lewis) Cave, Ripley County

Description

Characters: A white (albinistic) crayfish with small, unpigmented eyes and long slender pincers. Rostrum with a central, troughlike depression, its margins nearly parallel and narrowing abruptly into a rather long acumen. In males the gonopod has two terminal processes that are at nearly right angles to the main gonopod axis, and the primary (central) process is only

slightly recurved and bladelike.

Life Colors: Nearly white and without pigment, the gills and other internal structures visible through the translucent exoskeleton of small individuals.

Size: Adult females are about 2.3 to 3.2 inches in length; adult males are about 2.4 to 3.7 inches long.

Scientific Name: *hubrichti*, named for Leslie Hubricht, its discoverer.

Most Like: Bristly cave crayfish (*Cambarus setosus*).

Differs: Differs from bristly cave crayfish in the following respects: areola present; margins of rostrum converging slightly or not at all anteriorly, with acumen much longer than basal segment of antennule; antennal scale rounded on its anterior margin; epistome (tonguelike extension above mouth) without lateral spines; primary process of male gonopod short, only slightly recurved and with shallow notch near tip; setae on pincers short and inconspicuous.

Distribution and Habitat

The Salem cave crayfish occurs only in the east-central Ozarks of Missouri, from Camden and Crawford counties south to Howell and Ripley counties. It is present in drainages on both slopes of the main Ozark drainage divide, including the Meramec, Gasconade and Osage rivers to the north and the Current, Eleven Point and Spring rivers to the south.

This crayfish has been observed in a wide variety of habitats, including cave streams over rock, sand, mud and bat guano substrates;²⁶ the margins of deep, subterranean lakes over organic debris; and the orifices of large springs near the limit of daylight at depths of 40 to 140 feet. Specimens also have been collected in daylight from the outflow of a small spring, a pool in the bottom of a large, deep sink and the ruts left by a truck that became stuck in an Ozark fen. Other species of crayfish occur only rarely in the subterranean habitats that the Salem cave crayfish usually occupies. The spothanded crayfish (*O. punctimanus*) occurs more frequently in subterranean habitats than other stream-dwelling crayfish that occupy the range of the Salem cave crayfish.

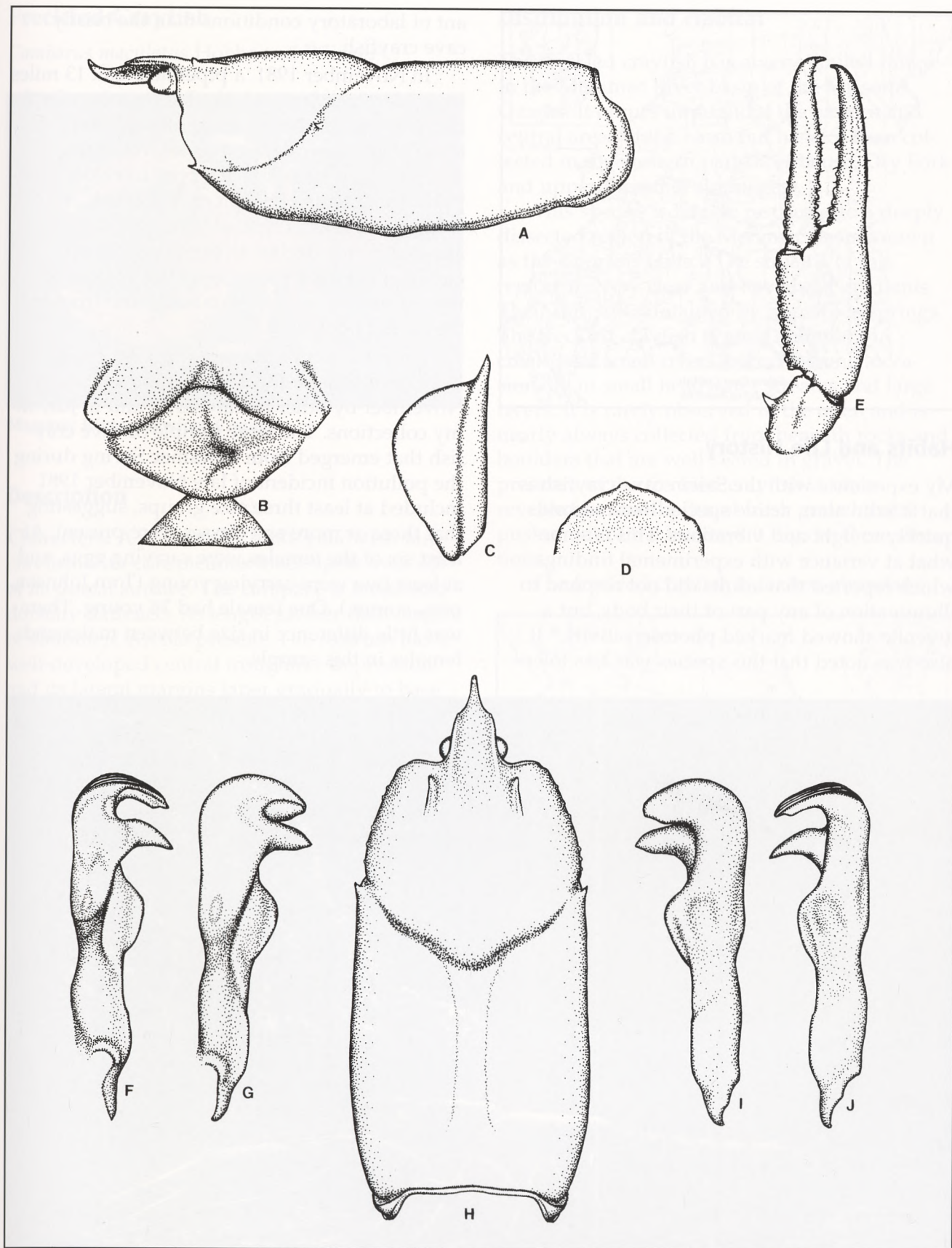
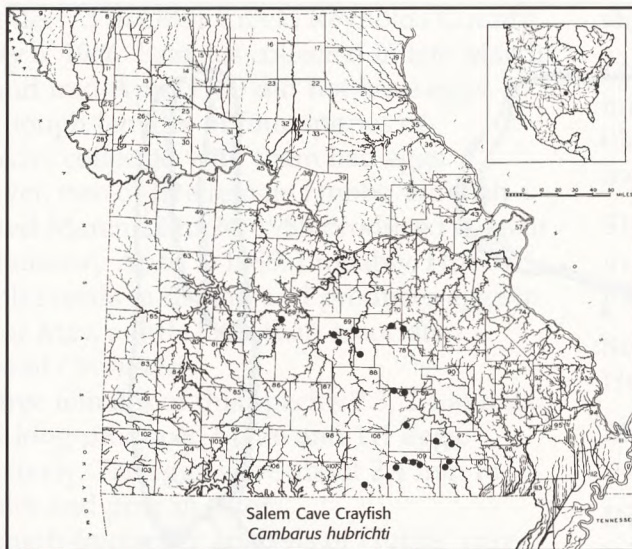


Plate 5. - *Cambarus hubrichti*. A, lateral view of carapace; B, female sperm receptacle; C, antennal scale; D, epistome; E, dorsal view of right pincer; F, mesial view of Form I male gonopod; G, mesial view of Form II male gonopod; H, dorsal view of carapace; I, lateral view of Form II male gonopod; J, lateral view of Form I male gonopod.



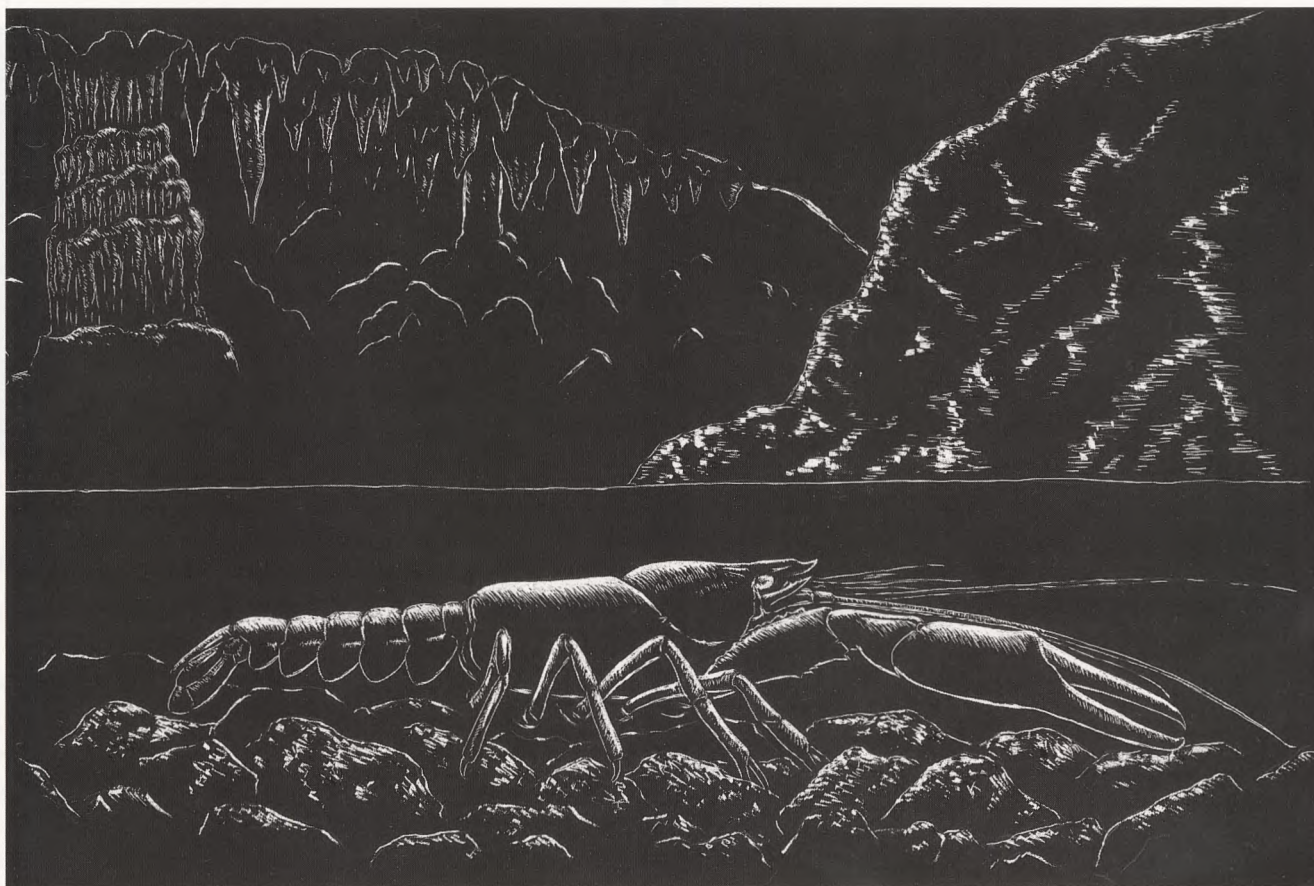
Habits and Life History

My experience with the Salem cave crayfish is that it is an alert, active species that responds quickly to light and vibrations. This is somewhat at variance with experimental findings which reported that adults did not respond to illumination of any part of their body, but a juvenile showed marked photosensitivity.⁸⁶ It also was noted that this species was less toler-

ant of laboratory conditions than the bristly cave crayfish.

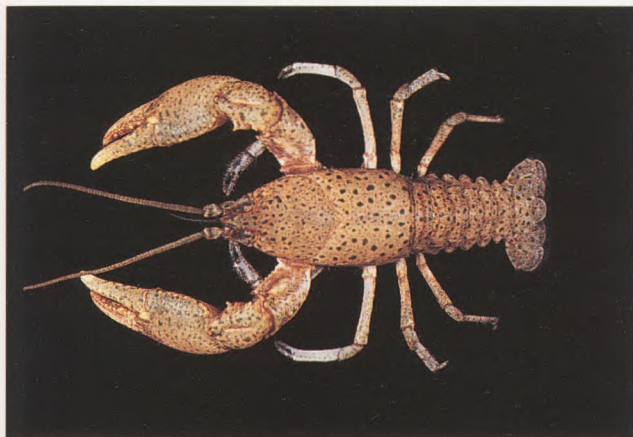
In November 1981, a pipeline break 13 miles from Maramec Spring leaked ammonium fertilizer into the subterranean aquifer which feeds the spring, causing the oxygen level of the water to drop from above 6 ppm to below 1 ppm. Thousands of Salem cave crayfish and southern cavefish (*Typhlichthys subterraneus*), affected by the decline in the oxygen level, emerged from the spring opening.¹⁸ Many of these animals, as well as sculpins and trout in the spring pool, died.

Form I males of the Salem cave crayfish have been collected in March, June and November by other researchers,⁴² and in July in my collections. The large sample of cave crayfish that emerged from Maramec Spring during the pollution incident of late November 1981 included at least three size groups, suggesting that three or more age classes were present. At least six of the females were carrying eggs, and at least two were carrying young (Tom Johnson, pers. comm.). One female had 38 young. There was little difference in size between males and females in this sample.



Freckled Crayfish

Cambarus maculatus Hobbs and Pflieger



Meramec River, Crawford County

Description

Characters: A powerfully built, yellowish-tan crayfish with conspicuous black spots over all of its dorsal surface. The carapace is broad and dorsally flattened, its length greater than length of abdomen. Areola present. The rostrum has a well-developed central troughlike depression and its lateral margins taper gradually to base of short acumen. The acumen has conspicuous tubercles at base and tip. In males the gonopod has two terminal processes that are at right angles to the main gonopod axis and the primary process is strongly curved and bladelike; hooks are present on the bases of the second pair of walking legs.

Life Colors: Pincers, carapace and abdomen with many roundish black spots on a nearly uniform yellowish-tan background.

Size: Adults are usually 1.9 to 3.3 inches long. Adult size is about the same for both sexes.

Scientific Name: *maculatus*, Latin, meaning "spotted."

Most Like: Hubbs' crayfish (*Cambarus hubbsi*).

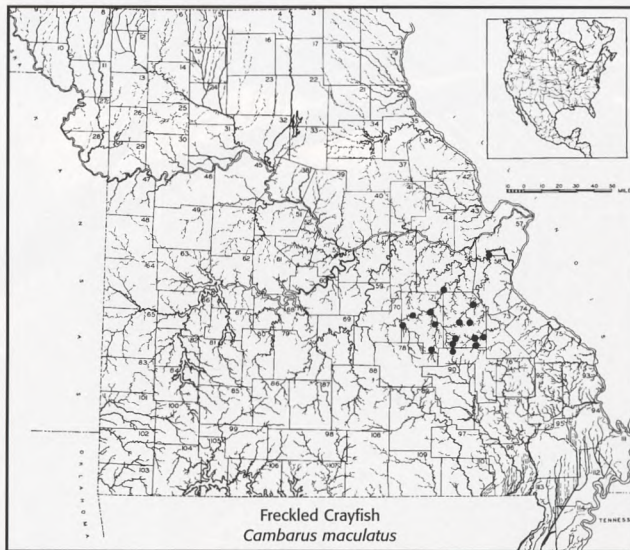
Differs: Differs most notably from Hubbs' crayfish in having black spots and lacking a black saddle mark across rear margin of carapace. Also, Form I males do not have a notch near tip of principal gonopod process and usually have 9 to 12 tubercles along inner margin of palm.

Distribution and Habitat

The freckled crayfish has a very limited range in the Meramec River basin of the Missouri Ozarks. It occurs throughout the eastern and central areas of the basin but has not been collected in the western part (Bourbeuse, Dry Fork and upper Meramec drainages).

This species is largely restricted to a deeply dissected region of the Meramec Basin known as the Courtois Hills.⁴⁴ The streams of this region are very clear and have high gradients. Their flow is maintained by numerous springs. The freckled crayfish is most abundant in creeks and small rivers, occurring only occasionally in small headwater streams and large rivers. It is rarely observed in the open and is nearly always collected from beneath rocks and boulders that are well-seated in gravel. The presence of the freckled crayfish is often revealed by small piles of fresh gravel that it pushes out of the burrows it digs in these situations.

The freckled crayfish is far less abundant



than the spothanded crayfish (*O. punctimanus*), golden crayfish (*O. luteus*) and saddlebacked crayfish (*O. medius*), with which it is frequently associated. It is occasionally taken with the Big River crayfish (*O. harrisoni*) and woodland crayfish (*O. hylas*), neither very common in the Meramec Basin.

Habits and Life History

The freckled crayfish probably emerges from its burrows to feed at night, but this has not been

observed. It is not agile or a strong swimmer and is easily caught by hand.

Most males taken in late winter and early spring, February through April, and in fall, late September and October, were in the Form I condition. A Form I male collected May 5, 1986, molted to Form II on May 15. The freckled crayfish probably has an annual molting cycle in which males molt from Form I to Form II in late spring and back to Form I in early fall.

Mating probably occurs soon after the fall molt but has not been observed. Three of five females collected May 5, 1986, had eggs. Females collected in late March and mid-April did not have eggs. However, females of three species of *Orconectes* collected with them — spothanded crayfish, golden crayfish and saddlebacked crayfish — were carrying eggs. This suggests a somewhat later period of reproduc-

tion in the freckled crayfish. Three females 2.4, 2.5 and 2.7 inches in length carried 67, 63 and 127 eggs respectively. These eggs were 2.4 mm in diameter and were gray to nearly black in color.

Length-frequency analysis suggests that the freckled crayfish achieves lengths of about 0.6 to 1.3 inches by the end of its first growing season, and is about 1.8 to 2.4 inches long by the end of its second year. It appears to have a life span of at least four years. My studies suggest that females and males grow at about the same rate and achieve about the same maximum size and longevity.



The Meramec River, Crawford County, is habitat for the freckled crayfish, *Cambarus maculatus*. The golden crayfish, *Orconectes luteus*; saddlebacked crayfish, *O. medius*; and spothanded crayfish, *O. punctimanus*, also occur here.

Mark Sullivan

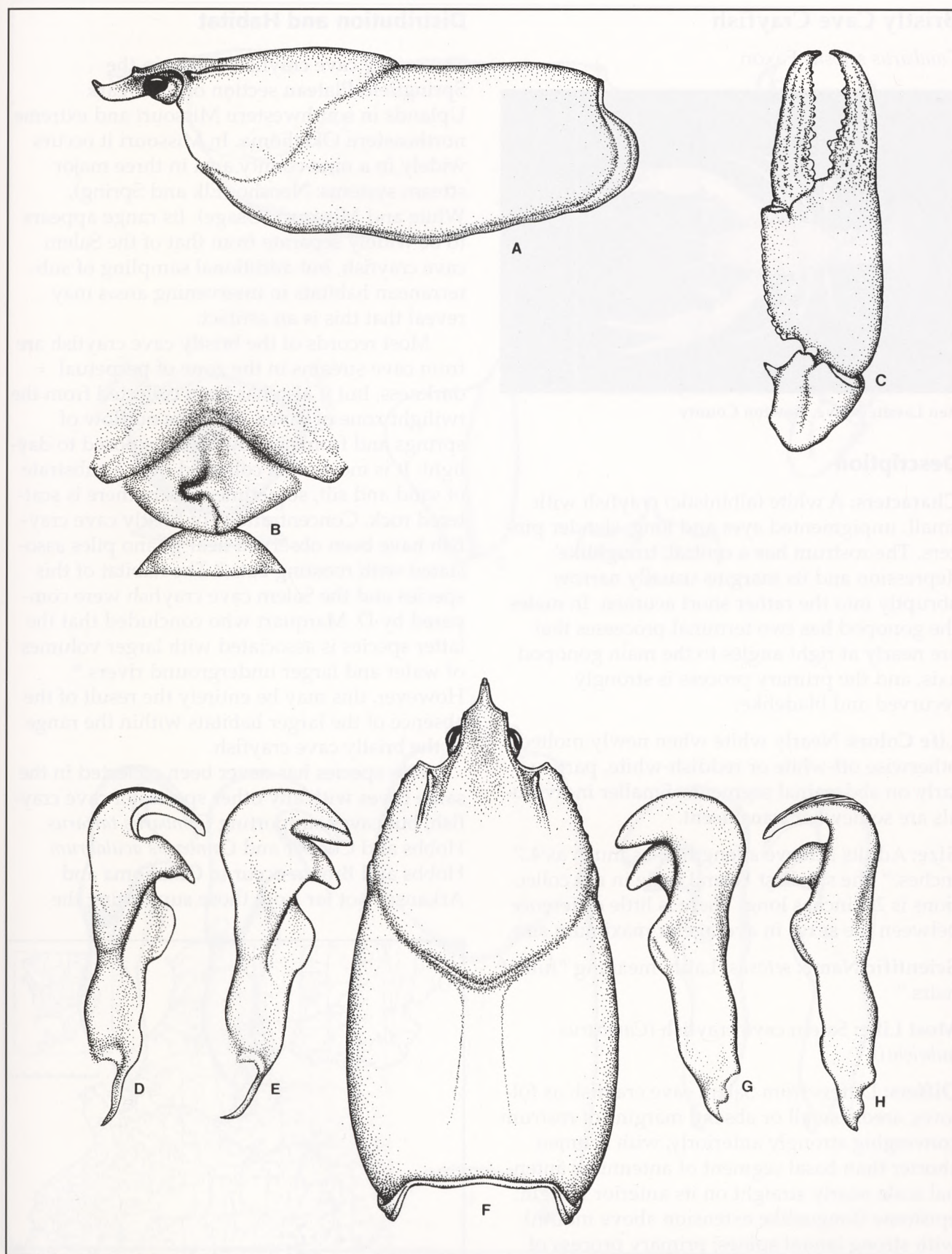


Plate 6. - *Cambarus maculatus*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

Bristly Cave Crayfish

Cambarus setosus Faxon



Ben Lassiter Cave, Newton County

Description

Characters: A white (albinistic) crayfish with small, unpigmented eyes and long, slender pincers. The rostrum has a central, troughlike depression and its margins usually narrow abruptly into the rather short acumen. In males the gonopod has two terminal processes that are nearly at right angles to the main gonopod axis, and the primary process is strongly recurved and bladelike.

Life Colors: Nearly white when newly molted; otherwise off-white or reddish-white, particularly on abdominal segments. Smaller individuals are somewhat translucent.

Size: Adults achieve a length of as much as 4.7 inches.⁷⁹ The smallest Form I male in my collections is 2.1 inches long. There is little difference between the sexes in average or maximum size.

Scientific Name: *setosus*, Latin, meaning "full of hairs."

Most Like: Salem cave crayfish (*Cambarus hubrichti*).

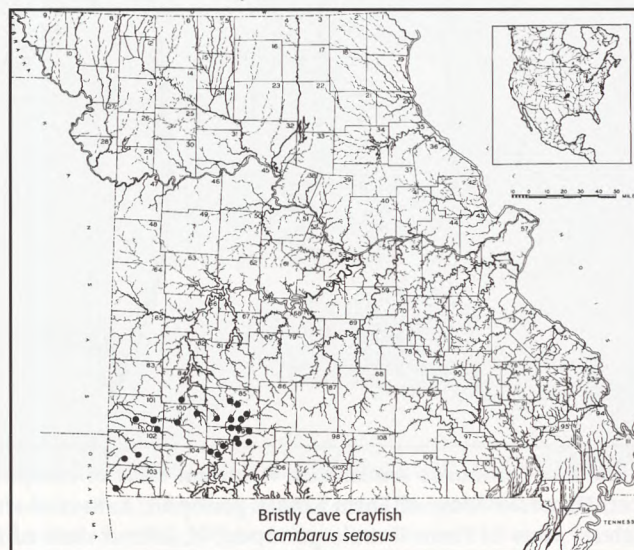
Differs: Differs from Salem cave crayfish as follows: areola small or absent; margins of rostrum converging strongly anteriorly, with acumen shorter than basal segment of antennule; antennal scale nearly straight on its anterior margin; epistome (tonguelike extension above mouth) with strong lateral spines; primary process of male gonopod long, strongly recurved and without a notch near its tip; setae on pincers long and conspicuous.

Distribution and Habitat

The bristly cave crayfish occurs in the Springfield Plateau section of the Ozark Uplands in southwestern Missouri and extreme northeastern Oklahoma. In Missouri it occurs widely in a nine-county area in three major stream systems: Neosho (Elk and Spring), White and Missouri (Osage). Its range appears to be widely separate from that of the Salem cave crayfish, but additional sampling of subterranean habitats in intervening areas may reveal that this is an artifact.

Most records of the bristly cave crayfish are from cave streams in the zone of perpetual darkness, but it also has been collected from the twilight zone of caves, from the outflow of springs and from shallow wells exposed to daylight. It is most often collected over a substrate of sand and silt, sometimes where there is scattered rock. Concentrations of bristly cave crayfish have been observed near guano piles associated with roosting bats.²⁶ The habitat of this species and the Salem cave crayfish were compared by D. Marquart who concluded that the latter species is associated with larger volumes of water and larger underground rivers.⁵⁶ However, this may be entirely the result of the absence of the larger habitats within the range of the bristly cave crayfish.

This species has never been collected in the same caves with any other species of cave crayfish, but caves supporting *Cambarus tartarus* Hobbs and Cooper and *Cambarus aculabrum* Hobbs and Brown occur in Oklahoma and Arkansas not far from those supporting the



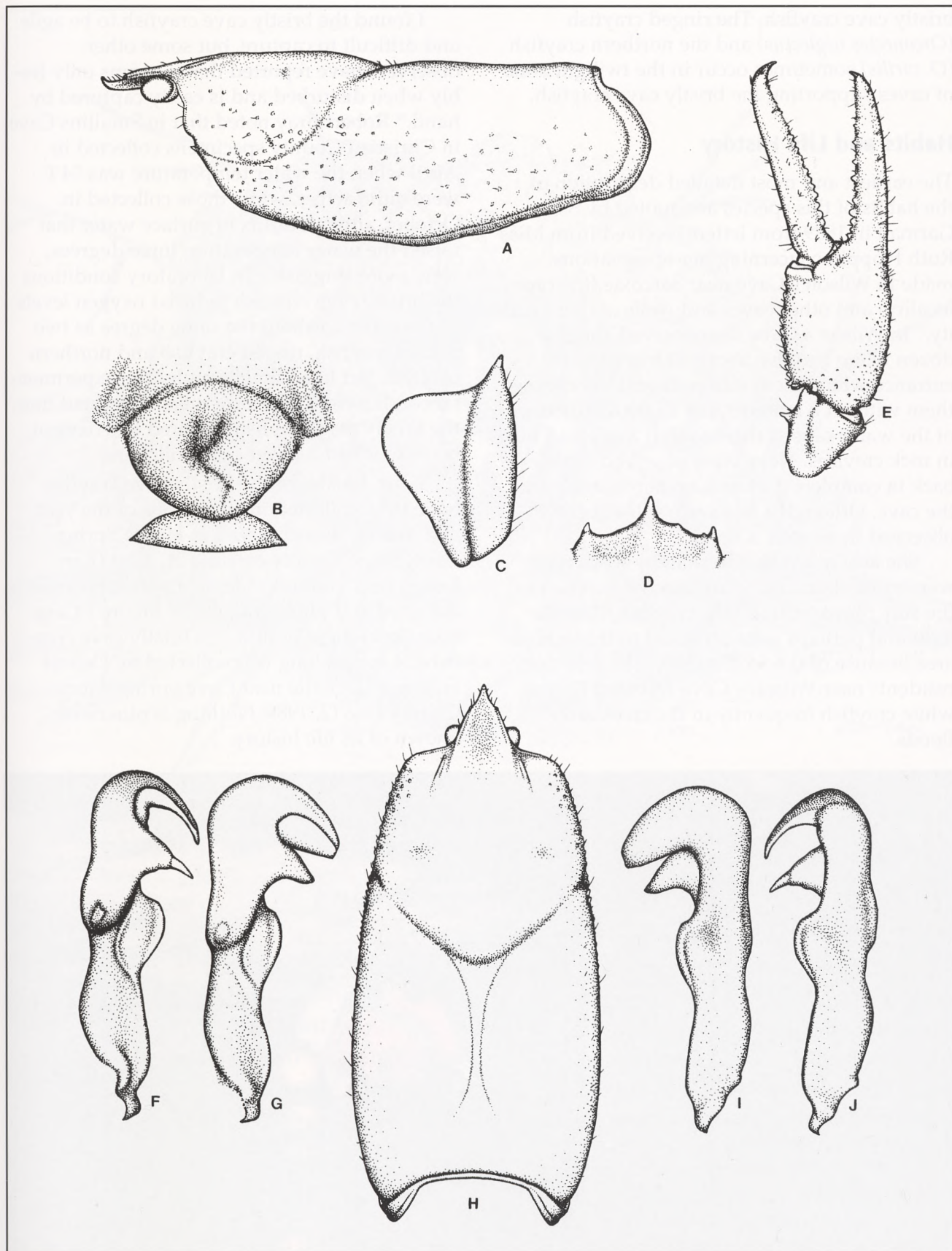


Plate 7. - *Cambarus setosus*. A, lateral view of carapace; B, female sperm receptacle; C, antennal scale; D, epistome; E, dorsal view of right pincer; F, mesial view of Form I male gonopod; G, mesial view of Form II male gonopod; H, dorsal view of carapace; I, lateral view of Form II male gonopod; J, lateral view of Form I male gonopod.

bristly cave crayfish. The ringed crayfish (*Orconectes neglectus*) and the northern crayfish (*O. virilis*) sometimes occur in the twilight zone of caves supporting the bristly cave crayfish.

Habits and Life History

The earliest and most detailed description of the habits of this species are quoted by S. Garman in 1889 from letters received from Miss Ruth Hoppin concerning her observations made in Wilson's Cave near Sarcoxie (the type locality) and other caves and wells of that vicinity.²⁷ In Wilson's Cave she observed about a dozen white crayfish about 10 feet from the entrance where there was sufficient light to see them without a lantern. Any slight disturbance of the water caused them to dart away and hide in rock crevices. None were observed farther back in complete darkness on her first trip into the cave, although a few were subsequently observed there after a flood.

She also noted that in shallow wells they were most abundant in wells more exposed to the sun. She concluded the crayfish liked the light and perhaps were attracted to the lighted area because of the food supply. She said that residents near Wilson's Cave reported finding white crayfish frequently in the creek after floods.

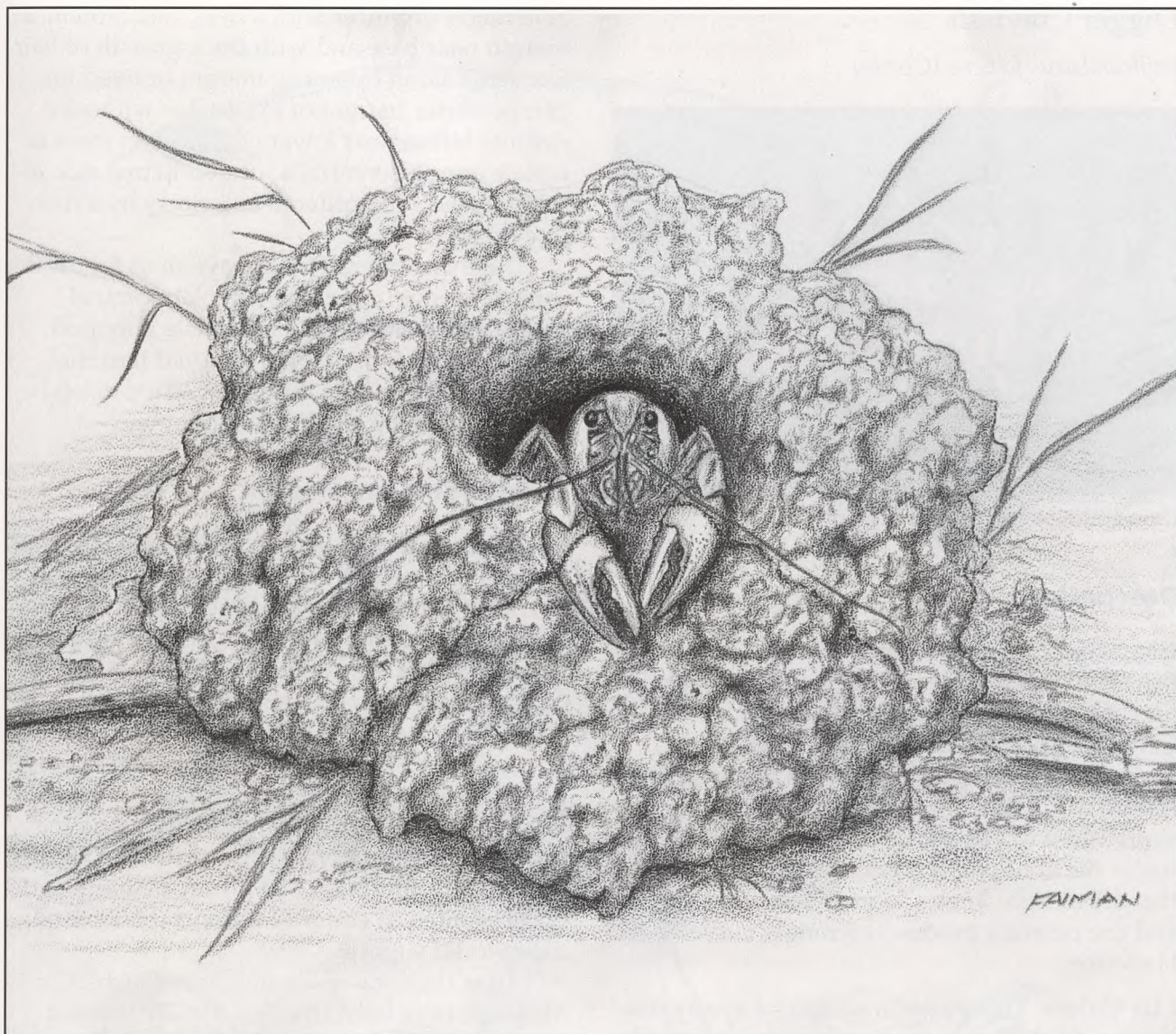
I found the bristly cave crayfish to be agile and difficult to capture, but some other observers have reported that it swims only feebly when disturbed and is easily captured by hand.⁸⁹ Robert Bray noted that in Smallins Cave in Christian County specimens collected in April when the water temperature was 54 F were quite active, while those collected in October, after an influx of surface water that raised the water temperature three degrees, were more sluggish.⁴¹ In laboratory conditions the bristly cave crayfish reduced oxygen levels of the water to about the same degree as two stream crayfish, ringed crayfish and northern crayfish, but lived longer under the experimental conditions.⁹ These observers suggested that the bristly cave crayfish required less oxygen because it had a lower metabolic rate.

Form I males of the bristly cave crayfish have been collected in all seasons of the year, and mating was observed in Hayes Spring Cave, Stone County on June 21, 1994 (Ken Lister, pers. comm.). A female with eggs was collected and photographed in Moore's Cave near Springfield in June.⁵⁸ A bristly cave crayfish 0.4 inches long was collected by Dennis Figg in a large tile near Cave Spring, Stone County Dec. 12, 1989. Nothing is otherwise known of its life history.



Biologist Ken Lister conducts an inventory of animals in Ben Lassiter Cave, Newton County. The bristly cave crayfish, *Cambarus setosus*, occurs here.

Jim Rathert



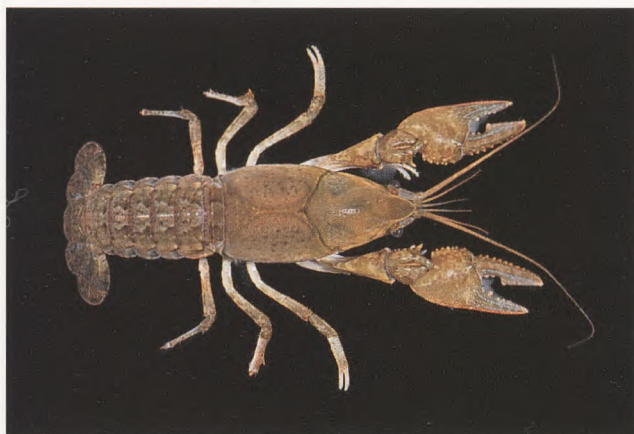
Fallicambarus Hobbs

This genus includes about a dozen species distributed primarily along the Atlantic and Gulf Coastal plain of the southern and eastern United States. Their most distinctive characteristic is the presence of a notch near the base of the cutting edge of the movable finger. The gonopod resembles that of species in the genus *Cambarus*.

A single burrowing species of this genus, the digger crayfish (*F. fodiens*), occurs in Missouri.

Digger Crayfish

Fallicambarus fodiens (Cottle)



Unnamed Slough, Gasconade County

Description

Characters: A heavy-bodied, reddish-tan crayfish with a pale, iridescent stripe along the midline of abdomen and short, broad pincers. Carapace approximately equal in length to abdomen; areola absent. Rostrum broad, with a central troughlike depression. Acumen very short and without lateral spines or tubercles. In males the gonopod has two terminal processes that are at right angles to main gonopod axis, and the primary process is strongly curved and bladelike.

Life Colors: The digger crayfish is a nearly uniform reddish-brown or olive-brown with a pale, iridescent stripe extending lengthwise along midline of abdomen. The abdominal stripe is bordered on each side by a less conspicuous blackish stripe. Specimens that are uniform in color or speckled have been reported from elsewhere in the range and may occur in Missouri.

Size: Adult specimens in my collections were 1.8 to 2.4 inches long, but sizes reported from elsewhere suggest a maximum length of about 3.5 inches.

Scientific Name: *fodiens*, Latin, meaning "to dig."

Most Like: Devil crayfish (*Cambarus diogenes*); superficially like grassland crayfish (*Procambarus gracilis*).

Differs: Differs from devil crayfish as follows: cervical groove discontinuous laterally; move-

able finger of pincer with a deep notch on inner margin near base and with thick growth of hair-like setae along opposing margin of fixed finger; posterior margin of eye socket without a definite bump near lower edge of eye; fossa of female annulus ventralis located to one side of midline and not bordered anteriorly by a definite ridge.

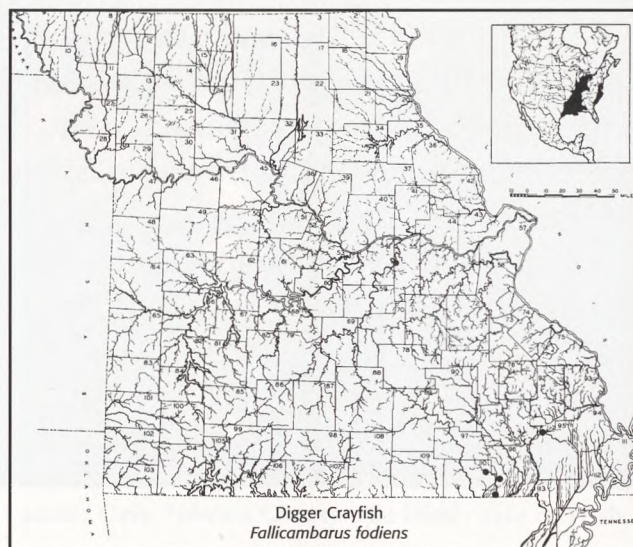
Differs from grassland crayfish as follows: carapace length nearly equal to abdominal length, not distinctly shorter; male gonopod with two, not four, strongly curved terminal processes; and a pale iridescent stripe extends lengthwise along midline of abdomen.

Distribution and Habitat

The digger crayfish occurs along the Gulf Coast from east Texas to the Florida panhandle and northward in the central Mississippi and lower Ohio valleys to the southern Great Lakes in Ontario and Michigan; also along the Atlantic Coast from Maryland to South Carolina.⁴⁵

In Missouri, this species is known from a few localities along the boundary between the Lowland Faunal Region and adjacent Ozarks and from a widely separate locality along the lower Gasconade River. This burrowing species is not easily collected, and it may be more widely distributed in eastern Missouri than existing data would suggest.

All collections of the digger crayfish in Missouri have been from seasonally flooded areas in lowlands and along the flood plains of streams. It was found in surface waters from January through May. This species spends most



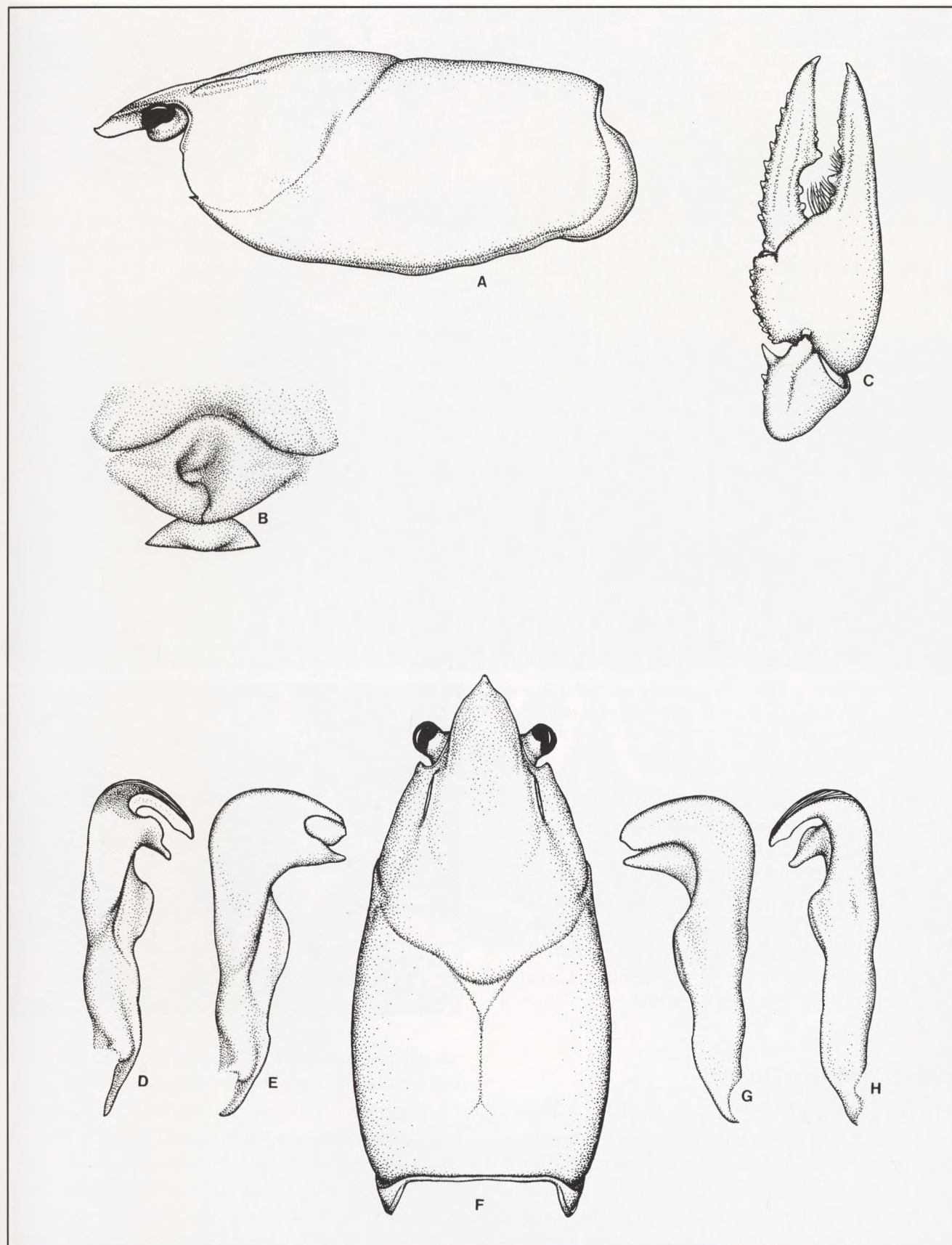


Plate 8. - *Fallicambarus fodiens*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.



(Above) Unnamed slough, Gasconade County; habitat of the digger crayfish, *F. fodiens*. (Right) Entrance to burrow of digger crayfish, *F. fodiens*; near unnamed slough, Gasconade County

of its life in burrows and for much of the year virtually the entire population is underground.

In Missouri the digger crayfish was found in association with four other species, all of which are characteristic inhabitants of low, seasonally flooded habitats. These are, in descending order of association, the shield crayfish (*F. clypeata*), vernal crayfish (*P. viaeveridus*), Cajun dwarf crayfish (*C. puer*) and white river crayfish (*P. acutus*).

Habits and Life History

The digger crayfish constructs the least complex burrows of any species in its genus.⁴⁵ Burrows often consist of a single nearly vertical shaft, its depth depending on the distance to groundwater, with a slight enlargement at its lower end. Frequently there is one, sometimes two or more, side passages leading from the vertical shaft to the surface or to a nearby stream or ditch. One or more of the surface openings is



usually capped by a chimney or mound consisting of mud brought up during excavation.

Burrows almost always extend downward to ground water and are entirely filled with water when the ground is saturated. As water levels recede during extended dry periods the openings are sealed with mud and the burrow may be extensively backfilled with mud, probably consisting of material that is a byproduct of continued burrowing to keep pace with the water table.

During periods of high atmospheric humidity, particularly during and after warm rains, the crayfish sit at the entrance to their burrows or wander over the surface of the ground, perhaps in search of food or mates, or to move to a new area. Their food consists of plant fragments, especially grass seeds, and a variety of animal material, including insect fragments and crayfish parts.⁷

A marking study in northcentral Ohio demonstrated that the digger crayfish often moved from burrow to burrow and that a bur-

row might be occupied successively or simultaneously by two or more individuals in every combination of sex or stage of maturity, even including individuals of a different species, the devil crayfish (*C. diogenes*). During midsummer, when the burrow entrances were plugged, these crayfish did not move from their burrows even when they were temporarily flooded by brief, heavy rains. One marked individual remained in its burrow for 249 days.⁶⁴

The Ohio study also revealed that the digger crayfish bred in late spring or early summer



(Top) Female of the digger crayfish, *Fallicambarus fodiens*, and (bottom) her molted shell; Sand Pond Conservation Area, Ripley County

and by October most mature females were carrying eggs containing embryos in an advanced stage of development. The eggs overwintered in this condition and hatched in late March or early April. On average each female carried 115 eggs or 74 young. The young of this species are free-living after their second molt, but remain with the female for about another week.⁹¹ In Ohio the digger crayfish reached sexual maturity toward the end of its second summer after hatching, and had a maximum life span of about six years.⁶⁴

In southern Illinois females with young have been found as early as February,⁶⁵ suggesting that the reproductive season at the latitude of southeastern Missouri may be somewhat advanced over that cited above for northcentral Ohio. No females with eggs or young occurred

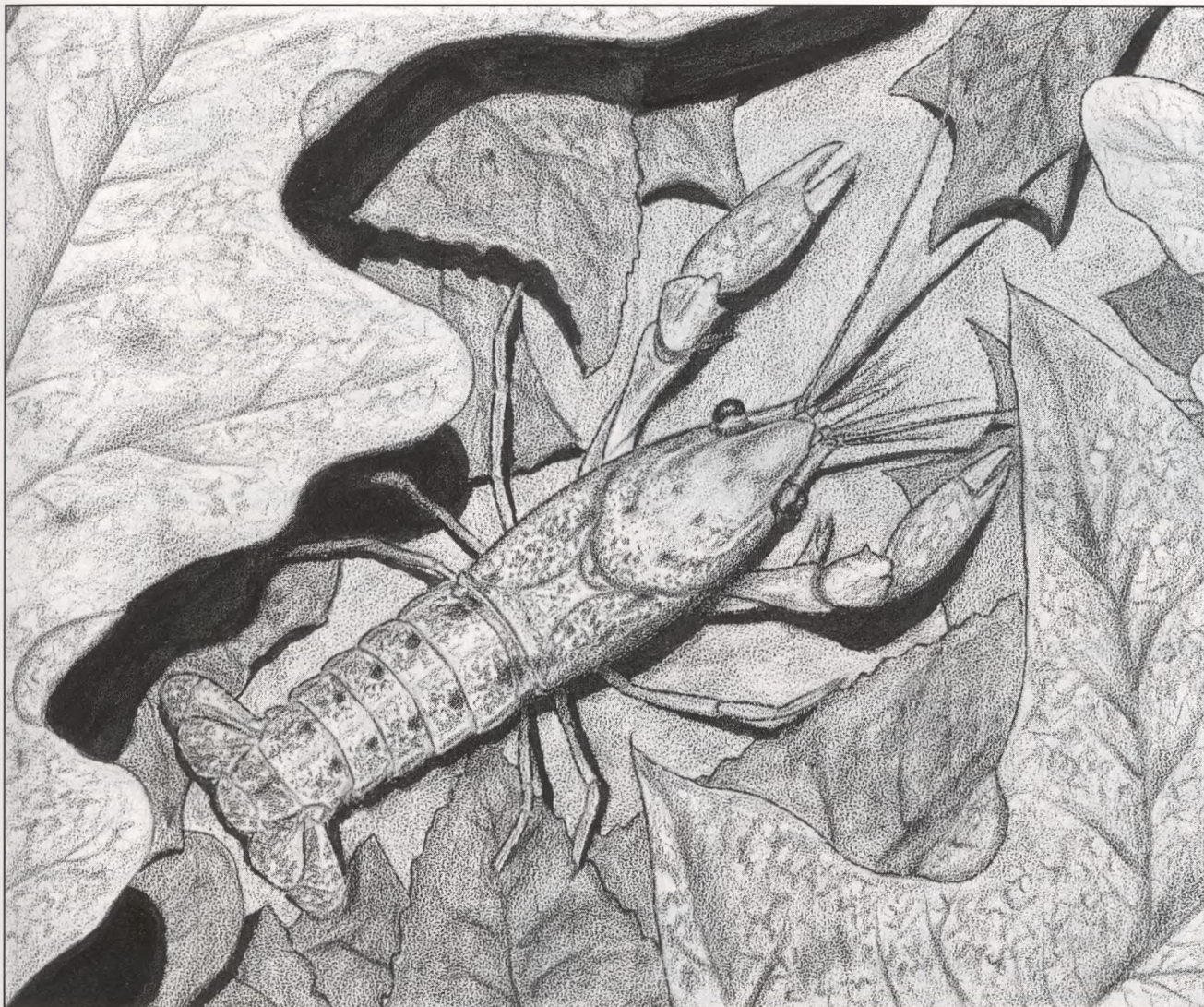
in my collections. A juvenile less than 0.4 inches long was collected in Butler County in mid-April (James Norrocky, pers. comm.). I have collected specimens less than an inch in length in late February, leading me to suspect that some young may hatch in fall or early winter at the latitude of southeastern Missouri.

A peculiar feature noted for the digger crayfish in Arkansas,⁴⁵ and also by me in Missouri, is the predominance of females. In Arkansas collections females were about twice as abundant as males among adults, and a collection of 30 juveniles less than an inch in length included only one male. Missouri collections contained 36 females and two males. Only one male was an adult. Apparently, this unbalanced sex ratio is present at birth, or develops very early in life. Its causes and significance are not known.



This swamp forest at Sand Pond Conservation Area, Ripley County, is habitat for five species of crayfish, including the shield crayfish, *Faxonella clypeata*. All of these species survive dry periods by burrowing.

Jim Rathert



Faxonella Creaser

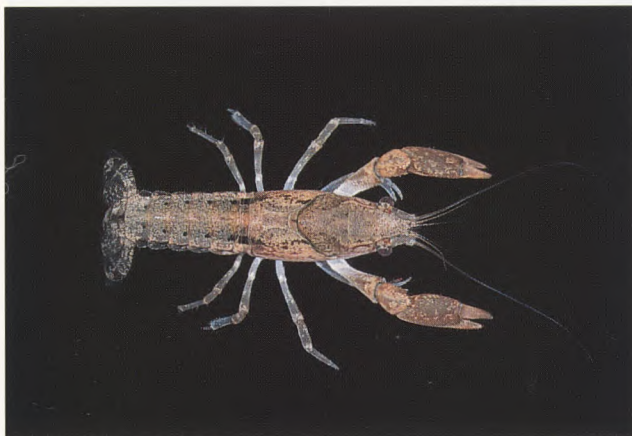
This genus contains four species that range along the Gulf Coast from eastern Texas to South Carolina and northward along the Mississippi River to southeastern Missouri. They are nearly as small as the dwarf crayfish (*Cambarellus*), achieving a maximum body length of about 2.0 inches.

A unique characteristic in male *Faxonella* is that the primary processes of the gonopods are much longer than the secondary processes, and the right and left primary processes overlap like crossed sabers when viewed from below.

A single species of this genus occurs in southeastern Missouri.

Shield Crayfish

Faxonella clypeata (Hay)



Roadside pool, Ripley County

Description

Characters: A small, reddish-tan crayfish with a pair of narrow, blackish lines or dashes extending lengthwise along dorsal surface of carapace and abdomen. Pincers narrow and cylindrical with short, abruptly tapering fingers. Areola present. Rostrum broad and without a central troughlike depression, its margins tapering into a short acumen that is without lateral spines or tubercles. In males, the gonopod has two terminal processes but appears to have only one because the primary process is long and conspicuous, while the secondary process is very short and easily overlooked. In ventral view, the primary processes of the right and left gonopods cross each other at an angle, like crossed sabers. Sperm receptacle of female freely moveable, not fused to sternum, and with two prominent knobs on its anterior margin.

Life Colors: Reddish-tan or olive-tan with a pair of narrow blackish lines or dashes extending lengthwise along the dorsal surface of carapace and abdomen.

Size: Adults are usually 0.8 to 2.0 inches long, with females somewhat larger than males.

Scientific Name: *clypeata*, Latin, meaning shield.

Most Like: Dwarf crayfish (*C. puer* and *C. shufeldtii*) and the young of other species.

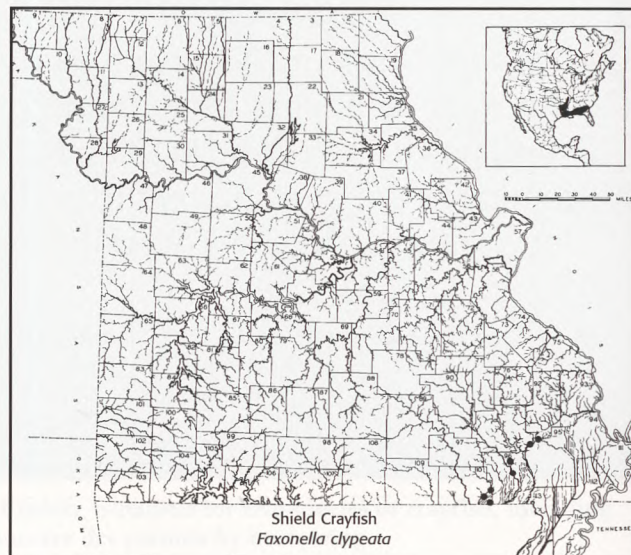
Differs: The dwarf crayfish differ from the shield crayfish in having the acumen set off from the rostrum by spines, in having three short terminal processes on male gonopod, and in their somewhat smaller adult size.

Distribution and Habitat

The shield crayfish occurs along the Gulf Coastal Plain from eastern Texas, and possibly southeastern Oklahoma, eastward to the Florida panhandle, then northeastward through Georgia and South Carolina; also present in the lower Mississippi Valley west of the Mississippi River, from Louisiana to southeastern Missouri.

In Missouri it has been collected at seven localities in a narrow zone along the boundary between the Ozark and Lowland faunal regions, from southeastern Ripley County northeastward to southern Bollinger County. All of my collections were from small intermittent creeks and the shallows of seasonally flooded sloughs and swamps. Its closest associates in these habitats were, in descending order of association, the digger crayfish (*F. fodiens*), vernal crayfish (*P. viaeveridus*), Cajun dwarf crayfish (*C. puer*) and white river crayfish (*P. acutus*). All of my collections were from surface waters during the period from mid-January to late May. For much of the year this species is sequestered in burrows.

The largest collections of the shield crayfish were from in or near relatively undisturbed habitats, and it probably was more widely distributed in southeastern Missouri before this area was ditched and drained.



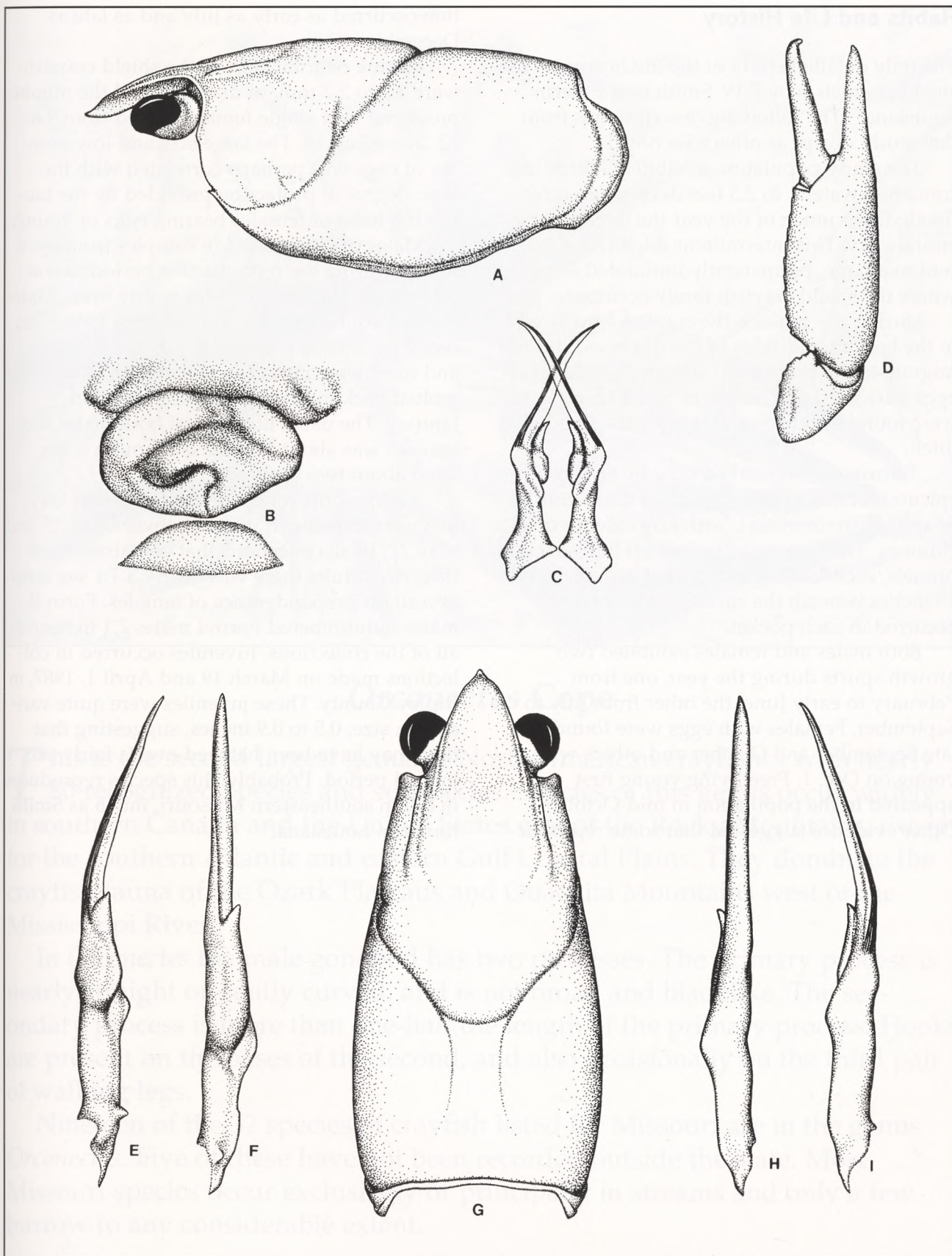


Plate 9. - *Faxonella clypeata*. A, lateral view of carapace; B, female sperm receptacle; C, form I male gonopods, in situ; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of form I male gonopod.

Habits and Life History

The only detailed study of the life history of the shield crayfish is by E.W. Smith in southern Louisiana.⁷⁸ The following description is from that study except as otherwise noted.

The study population inhabited a ditch that contained water 1 to 2.5 feet deep when fully flooded. For much of the year the ditch was entirely dry. This intermittent ditch was adjacent to a large, permanently inundated slough where the shield crayfish rarely occurred.

During dry periods the crayfish burrowed in the bottom and sides of the ditch and did not migrate to the permanent slough. Females with eggs burrowed, regardless of water levels, and were found in burrows alongside the flooded ditch.

Burrows were marked only by an inconspicuous entrance hole (less than three-fourths of an inch in diameter), with no evidence of a chimney. The burrow branched off into several tunnels, each leading to a pocket or "cell" 8 to 15 inches beneath the surface. One crayfish occurred in each pocket.

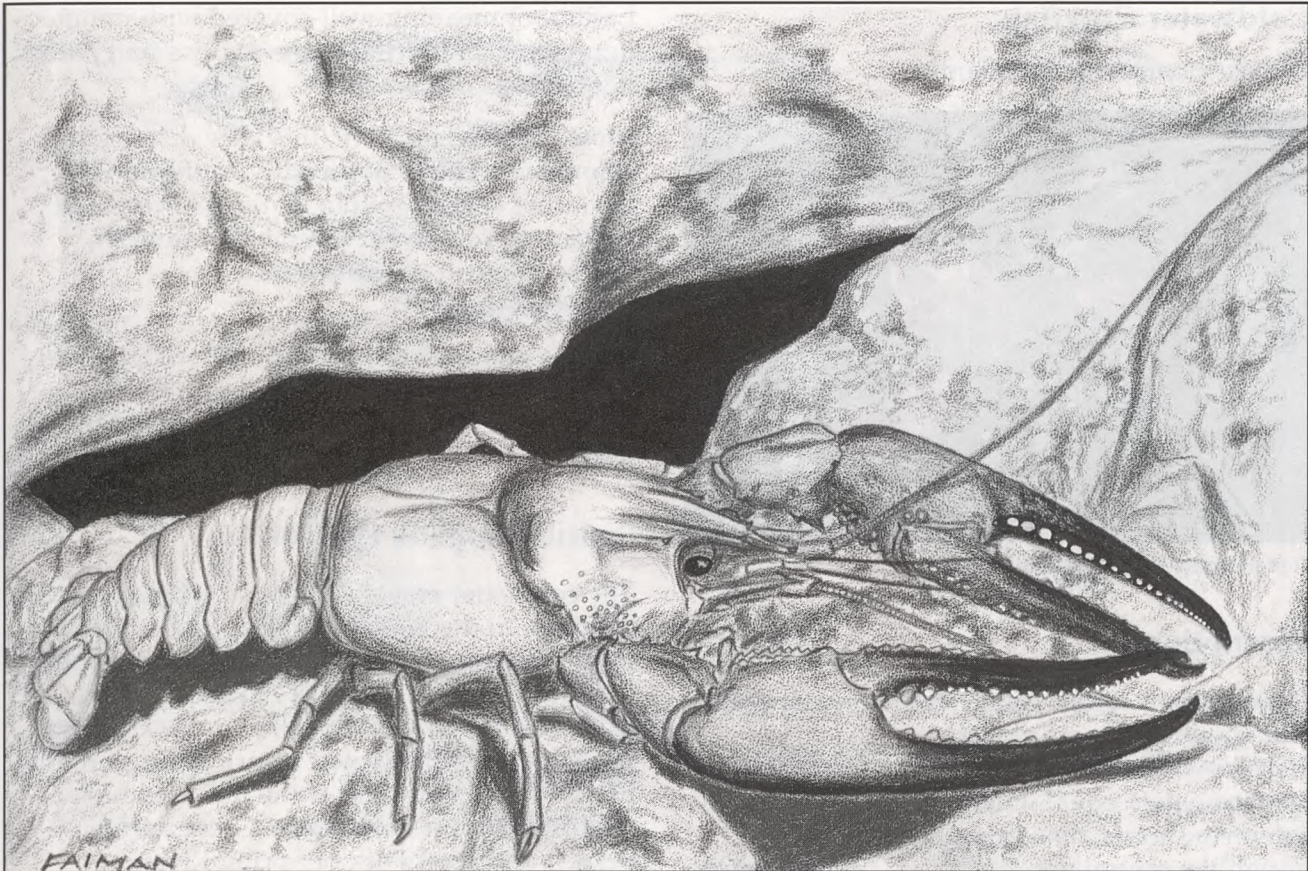
Both males and females exhibited two growth spurts during the year, one from February to early June, the other from July to September. Females with eggs were found in late September and October and others with young on Dec. 1. Free-living young first appeared in the population in mid-October. Other evidence suggested that some reproduc-

tion occurred as early as July and as late as December.

Mature ovarian eggs of the shield crayfish were 1.2 to 2.2 mm. in diameter and the number produced by a single female ranged from 9 to 12, averaging 14. The large size and low number of eggs was perhaps correlated with the high degree of protection provided by the burrowing habit of females bearing eggs or young.

Males predominated in samples from open waters during the reproductive period, but at other times the sex ratio was nearly even. Males molted from Form II to Form I prior to the breeding season, presumed to begin in May, and most were Form I in September. Many molted back to Form II in December and January. The usual life span of both males and females was about 1.5 years, although some lived about two years.

All Missouri collections of the shield crayfish were from open waters between Jan. 15 and May 22. In all collections that contained more than two adults there was nearly a 1:1 sex ratio or a slight preponderance of females. Form II males outnumbered Form I males 2:1 in nearly all of the collections. Juveniles occurred in collections made on March 19 and April 1, 1987, in Ripley County. These juveniles were quite variable in size, 0.5 to 0.9 inches, suggesting that they may have been hatched over a fairly prolonged period. Probably, this species reproduces in fall in southeastern Missouri, much as Smith found in Louisiana.⁷⁸



Orconectes Cope

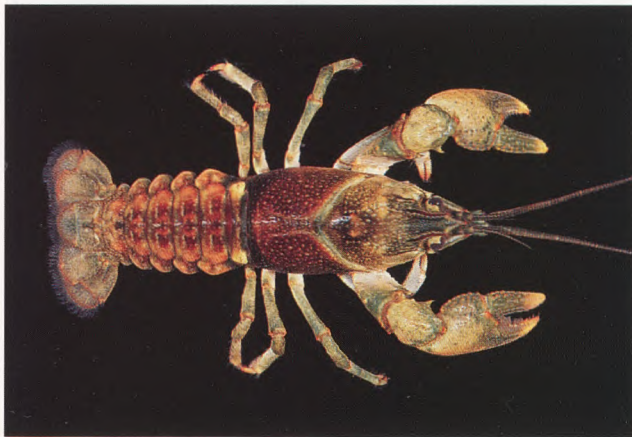
This is the second largest genus of North American crayfishes with nearly 80 recognized species and subspecies. Species of this genus occur widely in southern Canada and the United States east of the Rocky Mountains, except for the southern Atlantic and eastern Gulf Coastal Plains. They dominate the crayfish fauna of the Ozark Plateaus and Ouachita Mountains west of the Mississippi River.

In *Orconectes* the male gonopod has two processes. The primary process is nearly straight or gently curved, and is not broad and bladelike. The secondary process is more than one-half the length of the primary process. Hooks are present on the bases of the second, and also occasionally on the third pair of walking legs.

Nineteen of the 32 species of crayfish listed for Missouri are in the genus *Orconectes*. Five of these have not been recorded outside the state. Most Missouri species occur exclusively or principally in streams and only a few burrow to any considerable extent.

Coldwater Crayfish

Orconectes eupunctus Williams



Eleven Point River, Oregon County

Description

Characters: A rather small, stout crayfish with a blue-green head and pincers and a rich, reddish-brown thorax and abdomen. Carapace approximately equal in length to abdomen; antennae shorter than body. Rostrum with a troughlike central depression, its conspicuously thickened lateral margins set off by prominent spines or tubercles from well-developed acumen. Pincers moderately broad, the width of palm about equal to length of fixed finger. In males the gonopod has two short, nearly straight processes that are nearly equal in length and only the principal process has a corneous (yellowish translucent) tip. In females the sperm receptacle has a shallow anterior groove, flanked on each side by a low, rounded knob.

Life Colors: The most notable color features of this crayfish are the blue-green head and pincers, contrasting with the rich, reddish-brown carapace. Other distinctive features are the yellowish tips on the fingers and the small, whitish spot located laterally on each side of the first abdominal segment. Also, the abdomen has a dark reddish-brown, wedge-shaped central stripe that contrasts with the lighter colored yellowish-red margins. There is a narrow black saddle mark across the posterior margin of carapace and first abdominal segment. Sperm receptacle of female often blue-green.

Size: Adults are usually 1.2 to 2.8 inches in length. Males and females are similar in size.

Scientific Name: *eupunctus*, Greek prefix and

Latin root meaning well-covered with minute depressions, referring to the many small pitlike depressions on carapace.

Most Like: When alive, this very distinctively colored crayfish is not readily confused with any other species within its range. Preserved specimens somewhat resemble Mammoth Spring crayfish (*O. marchandi*).

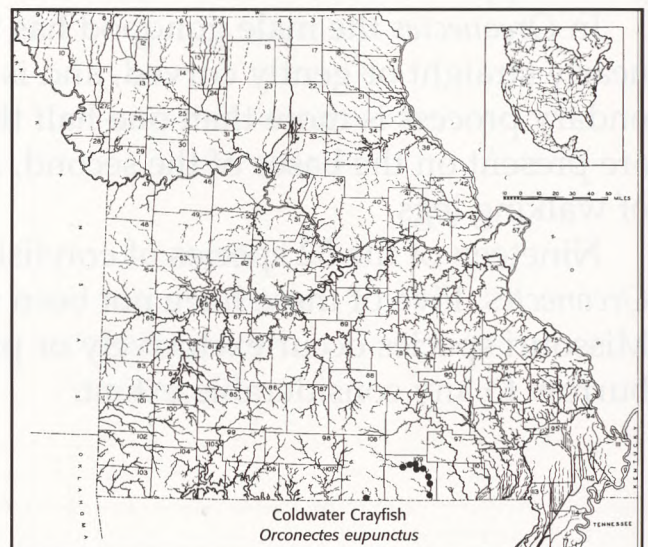
Differs: In Mammoth Spring crayfish, processes of male gonopod are curved, not straight, and sperm receptacle of female does not have a groove in anterior margin, as in coldwater crayfish.

Distribution and Habitat

The coldwater crayfish has a very localized distribution in the Eleven Point River and Spring River drainages of the Ozark Region in southern Missouri and northern Arkansas. These rivers are fed by Greer Spring and Mammoth Spring, two of the largest Ozark springs. In the Eleven Point River this is the most abundant crayfish and it is common in Greer Spring Branch and West Fork of Spring River.

The coldwater crayfish does not inhabit tributaries of Eleven Point River and does not ascend the river itself much above Greer Spring. It is most abundant over coarse gravel and rock substrate in swift, shallow water.

The only close associates of this species in its preferred habitat are the Ozark crayfish (*O. ozarkae*) and Hubbs' crayfish (*C. hubbsi*). The spothanded crayfish (*O. punctimanus*) is common along the margins and in backwaters of streams inhabited by the coldwater crayfish.



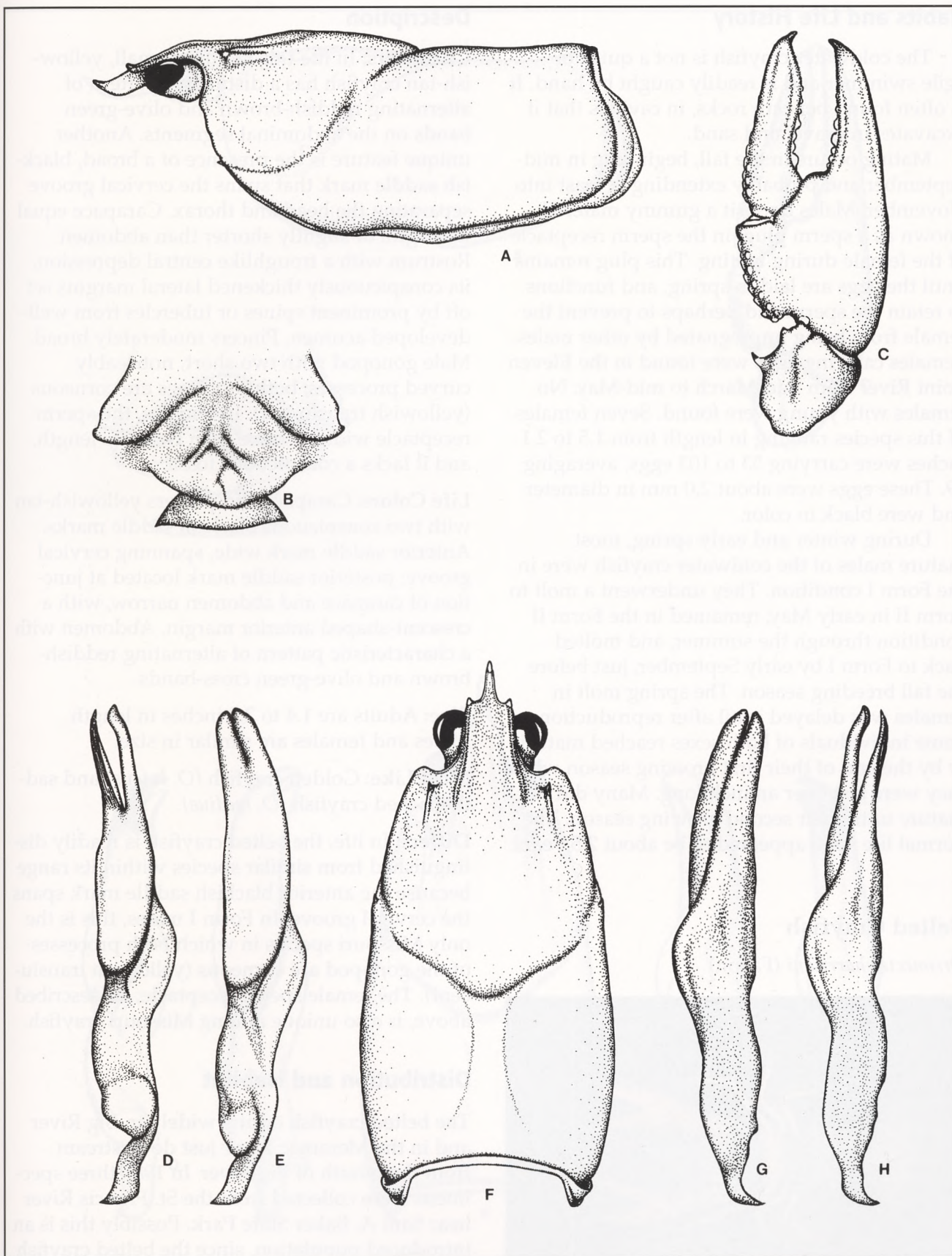


Plate 10. - *Orconectes eupunctus*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

Habits and Life History

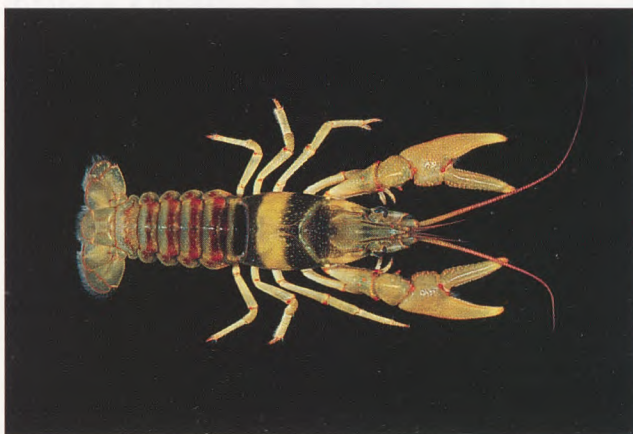
The coldwater crayfish is not a quick or agile swimmer and is readily caught by hand. It is often found beneath rocks, in cavities that it excavates in gravel and sand.

Mating occurs in the fall, beginning in mid-September and probably extending at least into November. Males deposit a gummy material, known as a sperm plug, in the sperm receptacle of the female during mating. This plug remains until the eggs are laid in spring, and functions to retain the sperm and perhaps to prevent the female from being impregnated by other males. Females carrying eggs were found in the Eleven Point River from mid-March to mid-May. No females with young were found. Seven females of this species ranging in length from 1.5 to 2.1 inches were carrying 53 to 103 eggs, averaging 79. These eggs were about 2.0 mm in diameter and were black in color.

During winter and early spring, most mature males of the coldwater crayfish were in the Form I condition. They underwent a molt to Form II in early May, remained in the Form II condition through the summer, and molted back to Form I by early September, just before the fall breeding season. The spring molt in females was delayed until after reproduction. Some individuals of both sexes reached maturity by the end of their first growing season when they were just over an inch long. Many did not mature until their second growing season. The normal life span appeared to be about 2.5 years.

Belted Crayfish

Orconectes harrisoni (Faxon)



Terre Bleue Creek, St. Francois County

Description

Characters: In life this medium-small, yellowish-tan crayfish has a distinctive pattern of alternating reddish-brown and olive-green bands on the abdominal segments. Another unique feature is the presence of a broad, blackish saddle mark that spans the cervical groove separating the head and thorax. Carapace equal in length, or slightly shorter than abdomen. Rostrum with a troughlike central depression, its conspicuously thickened lateral margins set off by prominent spines or tubercles from well-developed acumen. Pincers moderately broad. Male gonopod with two short, noticeably curved processes; both processes are corneous (yellowish translucent). In females, the sperm receptacle width is more than twice its length, and it lacks a conspicuous fossa.

Life Colors: Carapace and pincers yellowish-tan with two conspicuous blackish saddle marks. Anterior saddle mark wide, spanning cervical groove; posterior saddle mark located at junction of carapace and abdomen narrow, with a crescent-shaped anterior margin. Abdomen with a characteristic pattern of alternating reddish-brown and olive-green cross-bands.

Size: Adults are 1.4 to 2.6 inches in length. Males and females are similar in size.

Most Like: Golden crayfish (*O. luteus*) and saddlebacked crayfish (*O. medius*).

Differs: In life, the belted crayfish is readily distinguished from similar species within its range because the anterior blackish saddle mark spans the cervical groove. In Form I males, this is the only Missouri species in which both processes of the gonopod are corneous (yellowish translucent). The female sperm receptacle, as described above, is also unique among Missouri crayfish.

Distribution and Habitat

The belted crayfish occurs widely in Big River and in the Meramec River just downstream from the mouth of Big River. In 1987 three specimens were collected from the St. Francis River near Sam A. Baker State Park. Possibly this is an introduced population, since the belted crayfish has not been collected elsewhere in the St. Francis drainage. This species is endemic to the eastern Ozarks of Missouri.

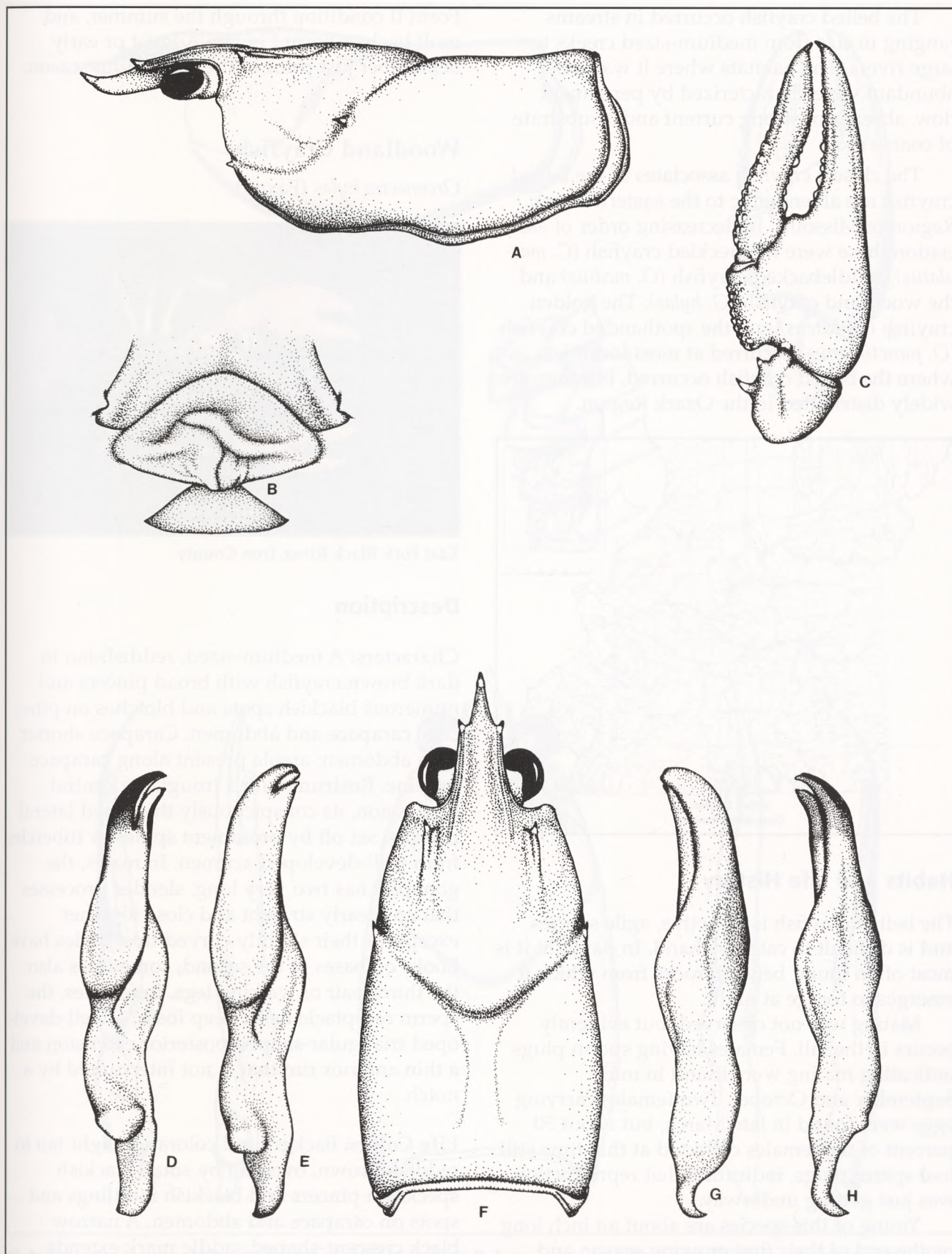
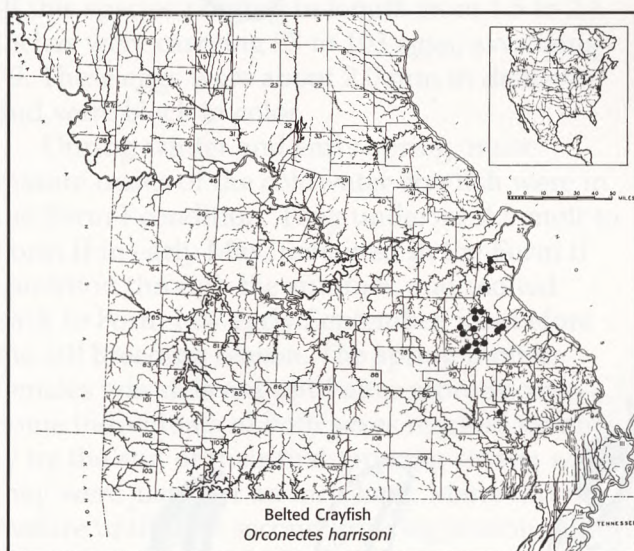


Plate 11. - *Orconectes harrisoni*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

The belted crayfish occurred in streams ranging in size from medium-sized creeks to large rivers. The habitats where it was most abundant were characterized by permanent flow, absence of strong current and a substrate of coarse rock.

The closest crayfish associates of the belted crayfish are all endemic to the eastern Ozark Region of Missouri. In decreasing order of association these were the freckled crayfish (*C. maculatus*), saddlebacked crayfish (*O. medius*) and the woodland crayfish (*O. hylas*). The golden crayfish (*O. luteus*) and the spothanded crayfish (*O. punctimanus*) occurred at most localities where the belted crayfish occurred, but they are widely distributed in the Ozark Region.



Habits and Life History

The belted crayfish is an active, agile species and is difficult to catch by hand. In daylight it is most often found beneath rocks from which it emerges to forage at night.

Mating was not observed, but evidently occurs in the fall. Females having sperm plugs indicating mating were found in mid-September and October. Two females carrying eggs were found in late March, but about 50 percent of the females collected at that time still had sperm plugs, indicating that reproduction was just getting underway.

Young of this species are about an inch long by the end of their first growing season and mature towards the end of their second summer of life. Males undergo a general molt from Form I to Form II in April or May, remain in the

Form II condition through the summer, and molt back to Form I in late August or early September just prior to the fall mating season.

Woodland Crayfish

Orconectes hylas (Faxon)



East Fork Black River, Iron County

Description

Characters: A medium-sized, reddish-tan to dark brown crayfish with broad pincers and numerous blackish spots and blotches on pincers, carapace and abdomen. Carapace shorter than abdomen; areola present along carapace midline. Rostrum with a troughlike central depression, its conspicuously thickened lateral margins set off by prominent spines or tubercles from well-developed acumen. In males, the gonopod has two very long, slender processes that are nearly straight and close together except for their slightly curved tips. Males have hooks on bases of the second, sometimes also the third, pair of walking legs. In females, the sperm receptacle has a deep fossa, a well-developed triangular-shaped posterior extension and a thin anterior rim that is not interrupted by a notch.

Life Colors: Background coloration light tan to reddish-brown, overlain by small blackish specks on pincers and blackish mottlings and spots on carapace and abdomen. A narrow black crescent-shaped saddle mark extends across posterior margin of carapace and first abdominal segment. This segment is usually flanked by a pair of small white spots.

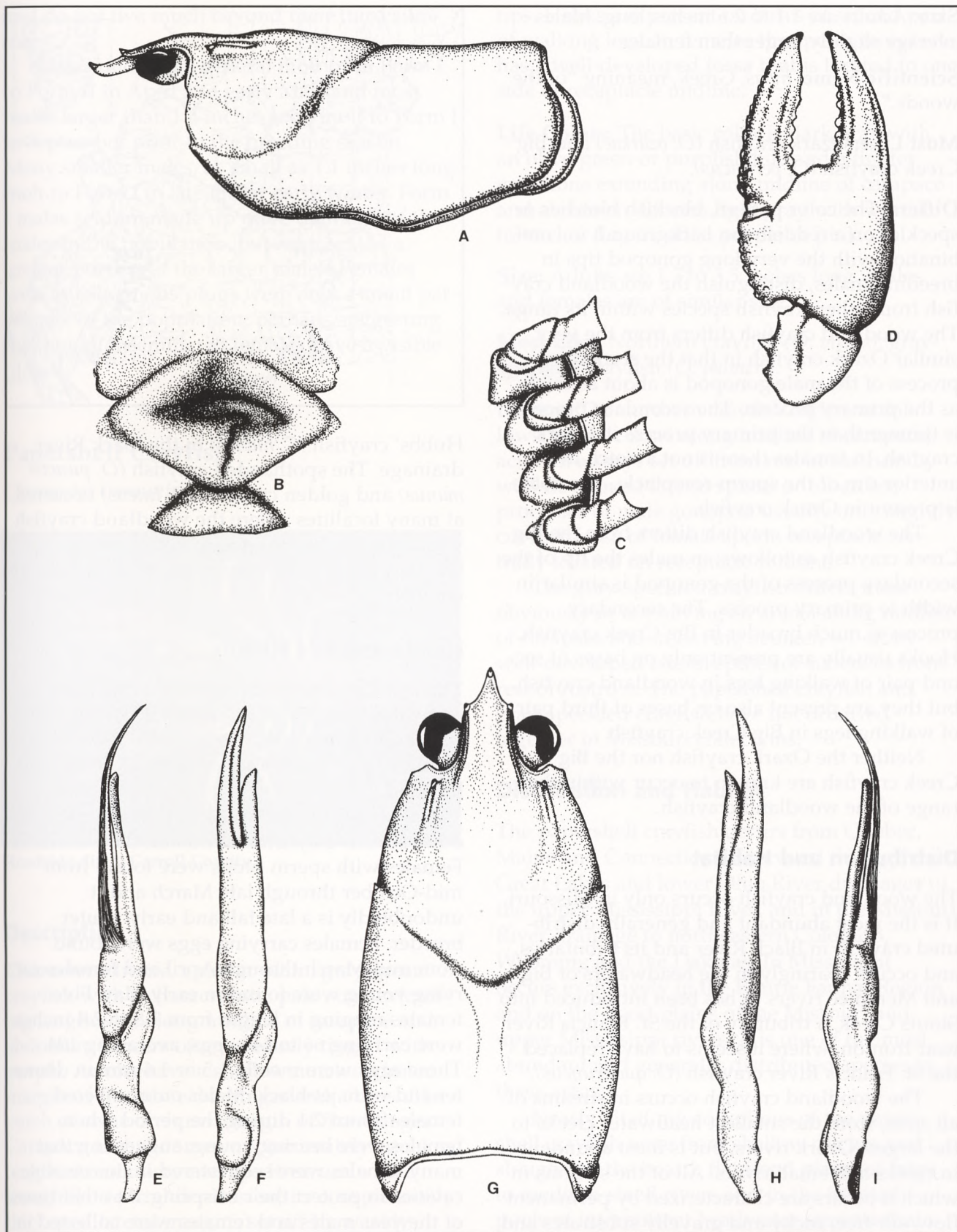


Plate 12. - *Orconectes hylas*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

Size: Adults are 1.1 to 2.6 inches long. Males average slightly larger than females.

Scientific Name: *hylas*, Greek, meaning "of the woods."

Most Like: Ozark crayfish (*O. ozarkae*) and Big Creek crayfish (*O. peruncus*).

Differs: The color pattern, blackish blotches or speckles on a reddish-tan background, in combination with the very long gonopod tips in breeding males, distinguish the woodland crayfish from other crayfish species within its range. The woodland crayfish differs from the very similar Ozark crayfish in that the secondary process of the male gonopod is about as thick as the primary process. The secondary process is thinner than the primary process in Ozark crayfish. In females there is not a notch in the anterior rim of the sperm receptacle. The notch is present in Ozark crayfish.

The woodland crayfish differs from the Big Creek crayfish as follows: in males the tip of the secondary process of the gonopod is similar in width to primary process. The secondary process is much broader in Big Creek crayfish. Hooks usually are present only on bases of second pair of walking legs in woodland crayfish, but they are present also on bases of third pair of walking legs in Big Creek crayfish.

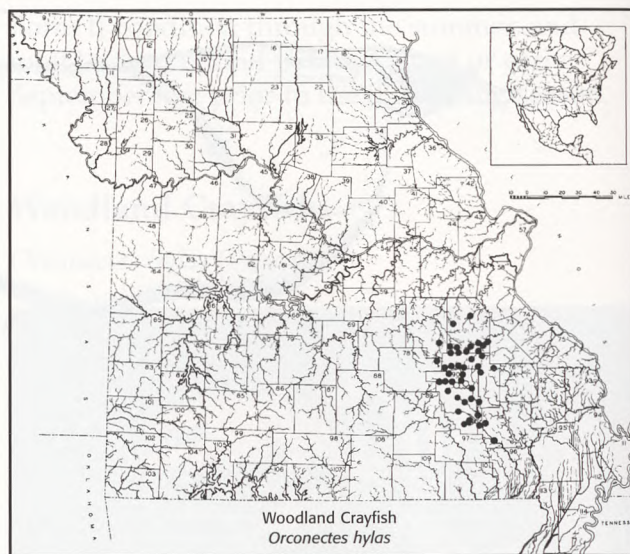
Neither the Ozark crayfish nor the Big Creek crayfish are known to occur within the range of the woodland crayfish.

Distribution and Habitat

The woodland crayfish occurs only in Missouri. It is the most abundant and generally distributed crayfish in Black River and its tributaries, and occurs sparingly in the headwaters of Big and Meramec rivers. It has been introduced into Stouts Creek, a tributary of the St. Francis River near Ironton, where it seems to have replaced the St. Francis River crayfish (*O. quadruncus*).

The woodland crayfish occurs in streams of all sizes, from the smallest headwater creeks to the largest Ozark rivers, but is most abundant in creeks and small rivers. All of the streams in which it occurs are characterized by permanent flow, silt-free, rocky and gravelly substrates and low turbidity.

The closest crayfish associates of the woodland crayfish are the belted crayfish (*O. harisoni*) in the Meramec River drainage and



Hubbs' crayfish (*C. hubbsi*) in the Black River drainage. The spothanded crayfish (*O. punctimanus*) and golden crayfish (*O. luteus*) occurred at many localities where the woodland crayfish was collected, but they also occur in many Ozark drainages not inhabited by the woodland crayfish.

Habits and Life History

The woodland crayfish lives in cavities that it excavates beneath rocks and boulders, in riffles, runs and silt-free rocky or gravelly pools. It is an alert, agile species and is difficult to capture by hand.

Its life history is similar to that of most other stream crayfish that inhabit the Ozarks. Females with sperm plugs were found from mid-October through late March and it undoubtedly is a late fall and early winter breeder. Females carrying eggs were found from mid-March through April and females carrying young were found in early May. Five females ranging in length from 1.8 to 2.4 inches were carrying 66 to 146 eggs, averaging 104. These eggs were mostly 1.5 or 1.6 mm in diameter and were jet-black. Males outnumbered females about 2:1 during the period when females were bearing young, suggesting that many females were sequestered in inaccessible cavities to protect their offspring. At other times of the year males and females were collected in approximately equal numbers.

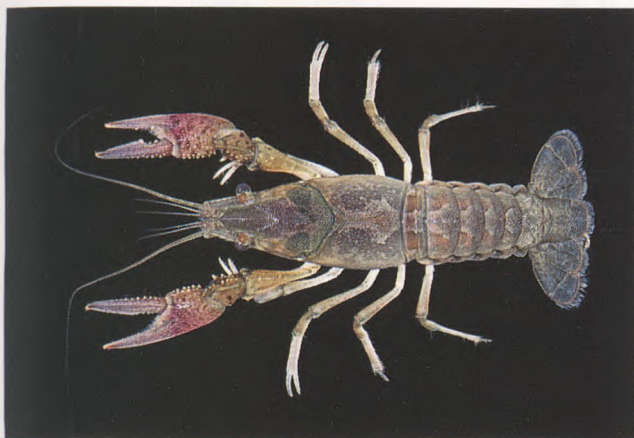
Juveniles are 0.6 to 1.1 inches in length by the end of their first growing season. Most do not mature until they are in their second year

and do not live much beyond their third summer.

Males undergo a general molt from Form I to Form II in April and early May, and most males larger than 1.6 inches long molt to Form I in September prior to the breeding season. Many smaller males, as small as 1.1 inches long, molt to Form I in late fall or early winter. Form I males seldom made up more than half of the males in the population, but represented a greater portion of the larger males. Females with mucilaginous plugs were only a small percentage of the population, perhaps suggesting that not all inseminated females have a visible plug.

Papershell Crayfish

Orconectes immunis (Hagen)



Roadside ditch, Carroll County

Description

Characters: In life, a rather plain, gray-green crayfish with a characteristic pale zone extending lengthwise along midline of carapace and abdomen. Pincers often uniquely tinged with purple. Adults have a shallow notch on inner margin of the moveable finger and a brushlike patch of setae on inner margin of fixed finger. Carapace and abdomen approximately equal in length. Areola very narrow. Rostrum with a troughlike central depression, its conspicuously thickened lateral margins set off by weakly developed spines or tubercles from acumen, or spines and tubercles absent. In males the gonopod has two rather short, strongly curved processes that are widely separate near their

tips. Hooks are present on bases of second pair of walking legs. In females the sperm receptacle has a well-developed fossa that is located to one side of receptacle midline.

Life Colors: The basic color is dark gray with an olive-green or purplish hue and a lighter gray zone extending along midline of carapace and abdomen. Pincers light gray with whitish tubercles; fingers often purple or pink.

Size: Adults are 1.7 to 3.5 inches long. Males and females are of similar size.

Most Like: Northern crayfish (*O. virilis*), gray-speckled crayfish (*O. palmeri*).

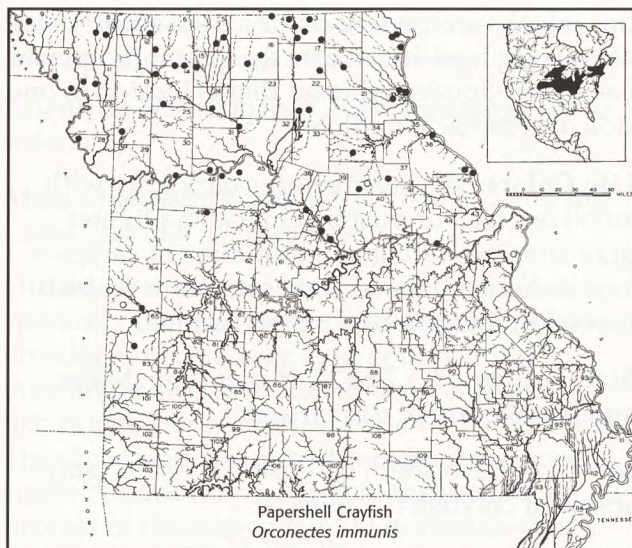
Differs: The northern crayfish differs as follows: no pale zone along midline of carapace; acumen always set off from rest of rostrum by well-developed lateral spines or tubercles; processes of male gonopod usually only slightly curved; fossa of female sperm receptacle centrally located on receptacle midline.

The gray-speckled crayfish differs most obviously in not having an areola along midline of carapace and in having acumen set off by well-developed lateral spines or tubercles from rest of rostrum. The papershell crayfish and gray-speckled crayfish have not occurred together in Missouri collections.

Distribution and Habitat

The papershell crayfish occurs from Quebec, Maine and Connecticut, westward through the Great Lakes and lower Ohio River drainages to the upper Mississippi River, and in the Missouri River drainage to northeastern Colorado, Wyoming and the Dakotas. In Missouri it occurs exclusively in the Prairie Faunal Region and on the flood plains of the Missouri and upper Mississippi rivers. It is one of the most abundant and generally distributed species in these areas.

Nearly all of my collections of the papershell crayfish were from shallow ditches and sloughs on the broad, flat flood plains of large to medium-sized rivers and in the isolated pools of intermittent headwater streams draining level upland prairies. Wide seasonal fluctuations in water area and depth (with many habitats becoming entirely dry during late summer), deep mud bottoms and absence of strong



flow or current are common characteristics of these habitats. Cover provided by extensive stands of aquatic plants or flooded terrestrial vegetation and thick deposits of water-soaked tree leaves or other plant debris also appeared to be desirable habitat features.

However, large populations of this crayfish occurred in habitats where high turbidity provided the only cover. The papershell crayfish was most abundant in habitats where predatory fish and other species of crayfish were scarce or absent. It burrows to avoid freezing or drying.

The papershell crayfish is not closely associated with any other species of crayfish in Missouri. The ubiquitous northern crayfish (*O. virilis*) occurred at nearly half the localities where I collected the papershell crayfish, but invariably one or the other of the two species was rare at these localities. Field and laboratory observations suggest that the northern crayfish aggressively excludes the papershell crayfish from permanent-water habitats.⁸ The papershell crayfish was thus restricted to habitats characterized by summer drying or low levels of dissolved oxygen, conditions that are less suitable for the northern crayfish. Competition from the red swamp crayfish (*P. clarkii*) and the white river crayfish (*P. acutus*) might be responsible for restriction of the papershell crayfish to small, rapidly-flowing upland streams in the Reelfoot Lake region.⁴³

The white river crayfish and the grassland crayfish (*P. gracilis*) were the only crayfish species other than the northern crayfish that occurred at more than one locality where I collected the papershell crayfish.

Habits and Life History

Excellent accounts of the life history of the papershell crayfish in hatchery ponds in New York and in natural waters of northwestern Iowa are available.^{82,10} The following summary is based on these reports unless otherwise noted.

Adults of this species are most active at night, while juveniles are active throughout the day. Algae scraped from the stems of aquatic plants and other submerged objects is an important food, but dead plant and animal remains, and small invertebrates also are eaten.

Burrowing activity is stimulated by drying of the habitat or the approach of winter. The burrows are usually simple affairs consisting of a single shaft, its diameter depending on the size of the crayfish. The burrow extends to the water table below the frost line and has a flask-like enlargement at the bottom. Sometimes the entrance is capped by a low chimney, but often the mud brought up during excavation is deposited as a mound or ridge. If the burrow is filled with water, a disturbance at the entrance often will stimulate the crayfish to come to the surface, or even to leave the water. During extended periods of dry or cold weather, the burrow is usually capped and may be back-filled for several inches.

Mating seems to occur occasionally at almost any time of year papershell crayfish are active. However, in New York mating is largely confined to the period from mid-June to mid-October with a peak in late August. In northwestern Iowa the eggs are normally laid in the fall, but if standing water is not available at that time of year, oviposition may be delayed until spring. In either case the eggs generally hatch in May and the young remain with the female for a week or more, until they complete two molts. They molt frequently during their first summer and may mature and mate their first year. However, most do not mature until their second summer. There is a heavy mortality among Form I males after the mating season and virtually none survive beyond the spring molt of the year following that in which they mature. Most females also die after producing their first brood, but a few survive to produce a second brood.

I collected females with eggs in Missouri during March and April, and by June juveniles

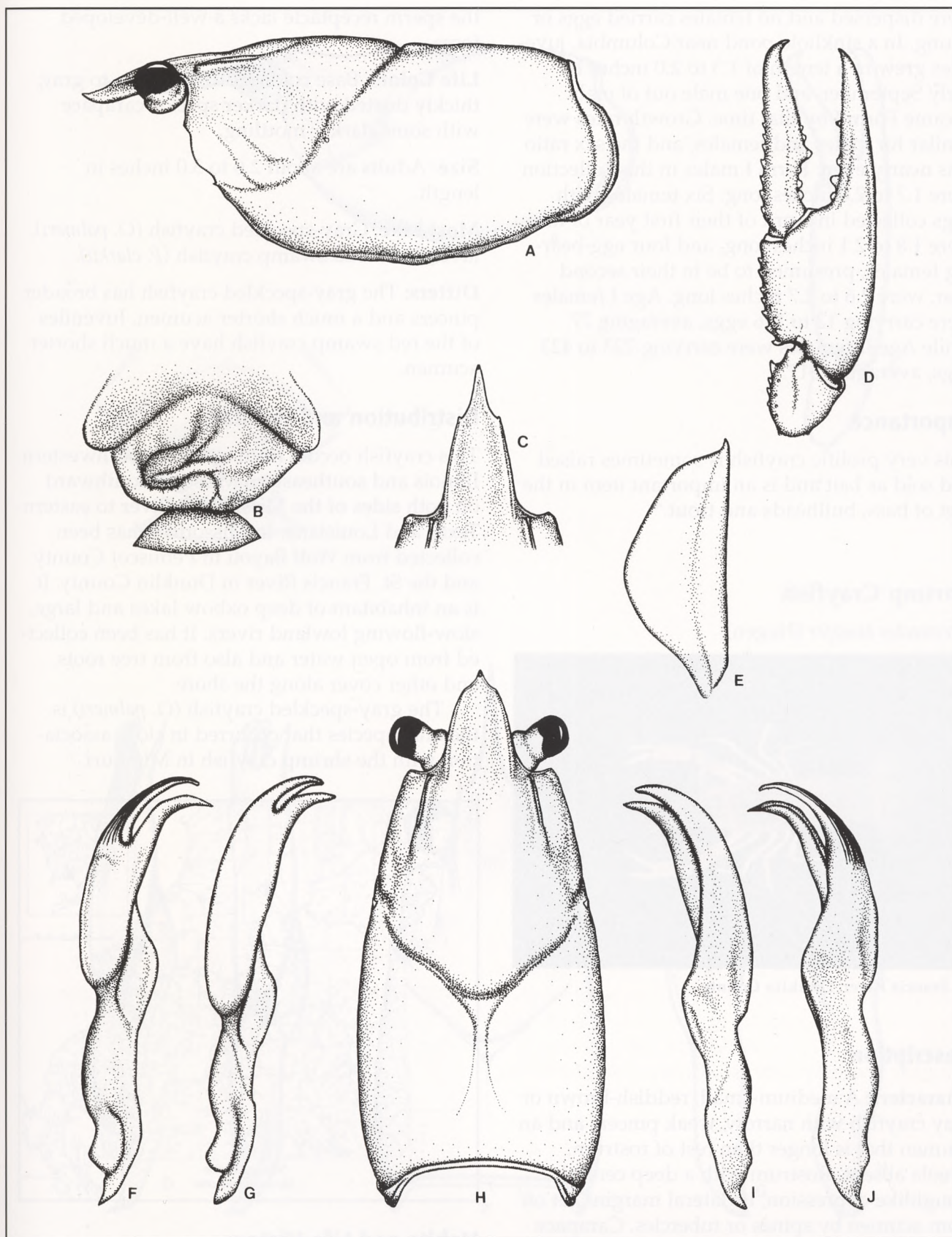


Plate 13. - *Orconectes immunis*. A, lateral view of carapace; B, female sperm receptacle; C, rostrum with lateral spines; D, dorsal view of right pincer; E, antennal scale; F, mesial view of Form I male gonopod; G, mesial view of Form II male gonopod; H, dorsal view of carapace; I, lateral view of Form II male gonopod; J, lateral view of Form I male gonopod.

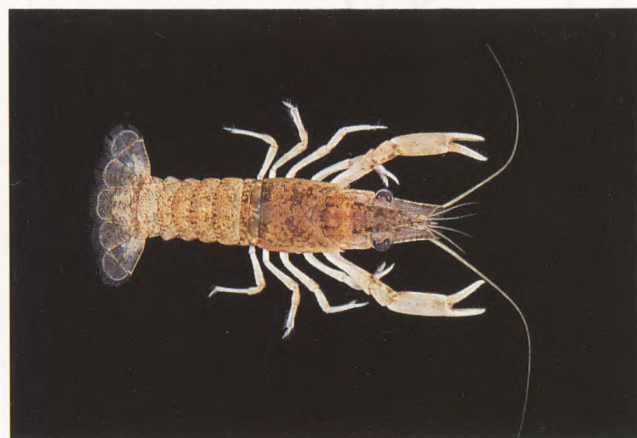
were dispersed and no females carried eggs or young. In a sinkhole pond near Columbia, juveniles grew to a length of 1.3 to 2.0 inches by early September, and one male out of eight became Form I by that time. Growth rates were similar for males and females, and the sex ratio was nearly even. Form I males in this collection were 1.7 to 2.0 inches long. Six females with eggs collected in April of their first year of life were 1.8 to 2.1 inches long, and four egg-bearing females, presumed to be in their second year, were 2.6 to 2.7 inches long. Age I females were carrying 12 to 126 eggs, averaging 77, while Age II females were carrying 223 to 423 eggs, averaging 317.

Importance

This very prolific crayfish is sometimes raised and sold as bait and is an important item in the diet of bass, bullheads and trout.⁸²

Shrimp Crayfish

Orconectes lancifer (Hagen)



St. Francis River, Dunklin County

Description

Characters: A medium-small, reddish-brown or gray crayfish with narrow, weak pincers and an acumen that is longer than rest of rostrum. Areola absent. Rostrum with a deep central troughlike depression, its lateral margins set off from acumen by spines or tubercles. Carapace and abdomen approximately equal in length. In males the gonopod has two very short terminal processes; the principal (yellowish-translucent) process is broad and shovel-shaped. In females

the sperm receptacle lacks a well-developed fossa.

Life Colors: Base color reddish-brown to gray, thickly dusted with darker specks; carapace with some darker mottling.

Size: Adults are about 2.0 to 3.0 inches in length.

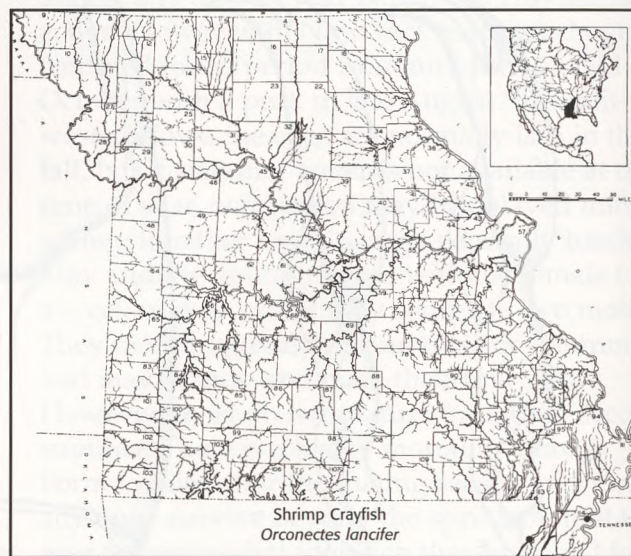
Most Like: Gray-speckled crayfish (*O. palmeri*), juveniles of red swamp crayfish (*P. clarkii*).

Differs: The gray-speckled crayfish has broader pincers and a much shorter acumen. Juveniles of the red swamp crayfish have a much shorter acumen.

Distribution and Habitat

This crayfish occurs from extreme southwestern Illinois and southeastern Missouri southward on both sides of the Mississippi River to eastern Texas and Louisiana. In Missouri it has been collected from Wolf Bayou in Pemiscot County and the St. Francis River in Dunklin County. It is an inhabitant of deep oxbow lakes and large, slow-flowing lowland rivers. It has been collected from open water and also from tree roots and other cover along the shore.

The gray-speckled crayfish (*O. palmeri*) is the only species that occurred in close association with the shrimp crayfish in Missouri.



Habits and Life History

A summary of life history information on this species in Louisiana indicated that Form I males were collected from August to November while

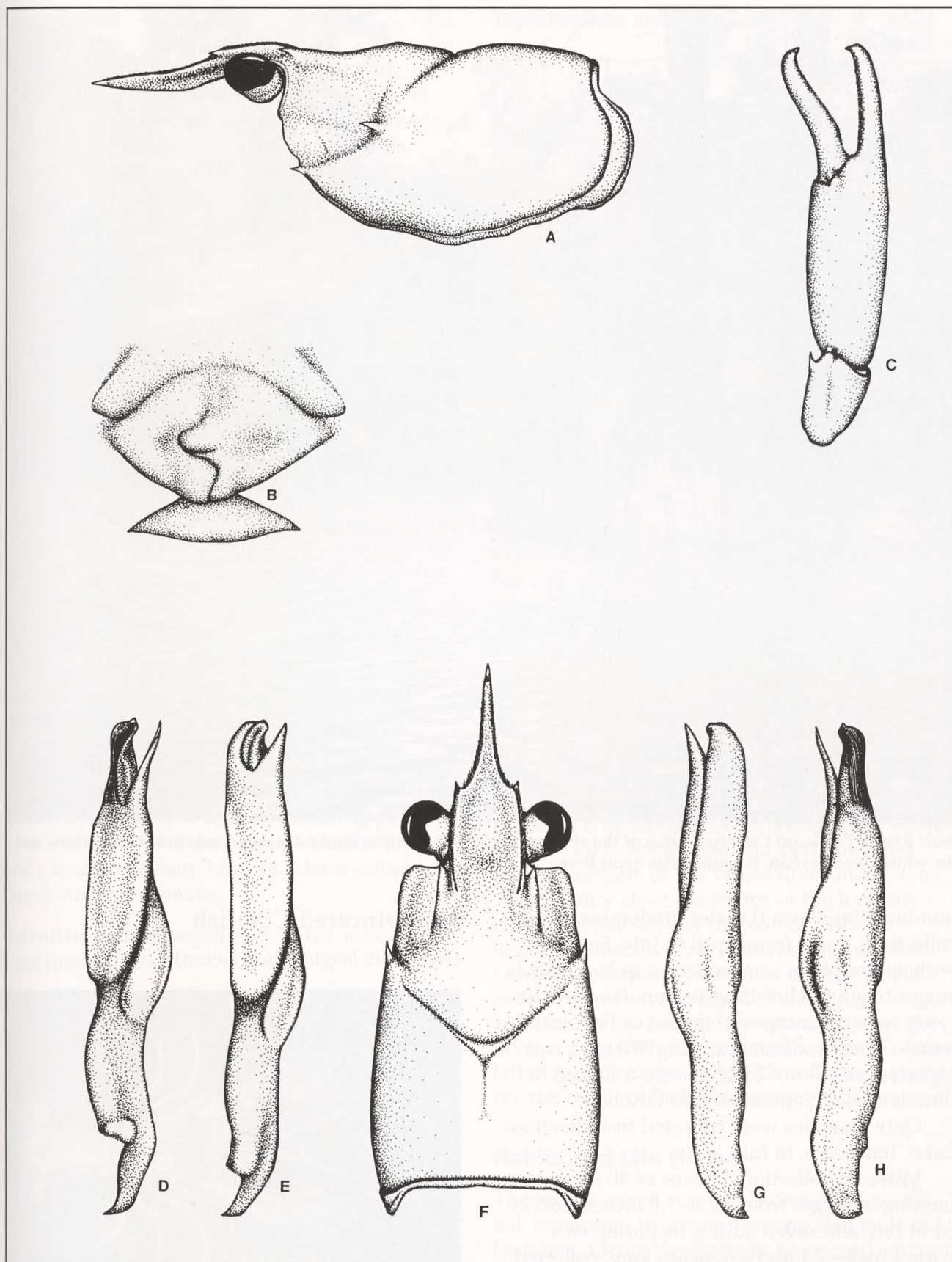


Plate 14. - *Orconectes lancifer*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.



Wolf Bayou, Pemiscott County; habitat of the shrimp crayfish, *O. lancifer*. Shufeldt's dwarf crayfish, *C. shufeldtii*, and the white river crayfish, *P. acutus*, also occur here.

non-breeding Form II males predominated in collections made from April to July. Females with sperm plugs were collected in November, suggesting a fall breeding season. Females carrying eggs or young were found in February.⁴ A female from Louisiana carrying 570 eggs was reported, and Form I males were collected in Illinois during September and October.⁶⁵

Only juveniles were collected from Reelfoot Lake, Tennessee, in July.

Missouri collections consist of 40 juveniles, ranging in length from 1.2 to 1.8 inches, collected in July and seven adults, including two Form I males 2.1 and 2.6 inches long, collected in September.

Longpincered Crayfish

Orconectes longidigitus (Faxon)

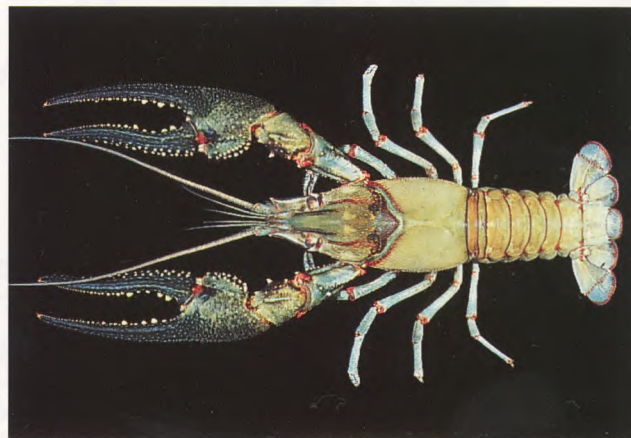


Table Rock Lake, Stone County

Description

Characters: A large, colorful crayfish with exceptionally long, slender pincers. Adults of this species frequently exceed 6 inches in body length and the pincers, including the palm, exceed length of carapace in adult males. Rostrum with a distinct central troughlike depression, its conspicuously thickened lateral margins set off by prominent spines from the acumen. Acumen very long, its length more than half length of rest of rostrum. Carapace length distinctly greater than length of abdomen. Areola present and well-developed. In males, the gonopods terminate in two elongate, slightly curved processes, and hooks are present only on bases of second pair of walking legs. In females the sperm receptacle has a deep depression (fossa) and a prominent anterior ridge with a definite notch at its midline.

Life Colors: The most distinctive color features include the dark, blue-black pincers, studded in adults with prominent yellowish or whitish knobs, and the uniformly-colored thorax. Carapace and abdomen olive-brown to reddish-brown, without definite darker mottlings or saddle marks. Segments and free margins of most body parts trimmed with bright red.

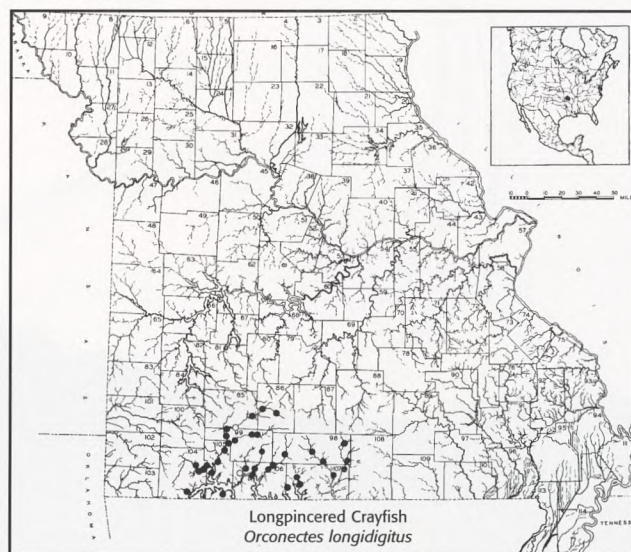
Size: The largest species of crayfish native to Missouri, reaching a body length of at least 6.0 inches and an overall length, including pincers, of more than 10.0 inches. Adults mature at a body length of about 3 inches. Males achieve a larger size than females.

Scientific Name: *longidigitus*, Latin, meaning long finger or toe.

Most Like: Spothanded crayfish (*O. punctimanus*) and northern crayfish (*O. virilis*).

Differs: The longpincered crayfish differs from the spothanded crayfish and the northern crayfish in its longer and proportionally narrower pincers and the longer acumen. In life, the longpincered crayfish has dark, blue-black pincers, compared with the greenish pincers of the other two species. The longpincered crayfish does not have a prominent black spot near base of moveable finger or a crescent-shaped dark bar across rear margin of carapace, as in spothanded crayfish.

Distribution and Habitat



The longpincered crayfish is restricted to the White River basin of southern Missouri and northern Arkansas. In Missouri it occurs throughout the basin, but does not achieve the high population densities of associated species such as the ringed crayfish or Ozark crayfish.

This species is an inhabitant of medium-sized to large, clear Ozark streams with permanent strong flow and predominantly silt-free substrates. In these streams its favored habitat is moderately deep pools along bluffs where rock slabs and large rubble provide crevices for hiding. Substantial populations of the longpincered crayfish also occur along rocky shorelines of Table Rock Lake and perhaps other large reservoirs of the White River main stem.

The only close associates of the longpincered crayfish are the ringed crayfish (*O. neglectus*) and the Ozark crayfish (*O. ozarkae*). Other less frequent associates of this species include Hubbs' crayfish (*C. hubbsi*), the spothanded crayfish (*O. punctimanus*) and the northern crayfish (*O. virilis*). Occurrence of the latter species in the White River Basin is probably the result of bait-bucket introductions.

Habits and Life History

The longpincered crayfish is decidedly nocturnal, remaining in crevices among slab rock and boulders during the daylight hours and emerging at dusk to prowl rocky pools in search of food. It is an alert, agile species and a strong swimmer. It is omnivorous and does not hesi-



Bull Creek, Taney County; habitat of the longpincered crayfish, *O. longidigitus*. The ringed crayfish, *O. neglectus* and Ozark crayfish, *O. ozarkae*, also occur here.

tate to capture and consume other crayfish if the opportunity arises.

The reproductive cycle of this species is similar to that of other *Orconectes* in Ozark streams. Form I males are present in the population throughout the year, but most males molt from Form II to Form I in August or September. *O. longidigitus* held in the laboratory mated in late September and early October, indicating a fall and early winter breeding season. Females with eggs were observed in early April and females with young were found in early to mid-May.

Growth of males and females is similar during the first summer of life and in streams they are about 1.4 to 2.0 inches long by late fall. Sexual maturity is not reached until the second year of life and the life span is probably three or more years. The largest specimens observed have been males.

Growth in ponds is more rapid than in streams, and some individuals mature by fall of

their first year of life. In an unfertilized pond near Columbia, without supplemental feeding, this species achieved a length of 3.1 to 4.0 inches by early September. Only one of 25 males captured on Sept. 10 was Form I, but nine of nine males captured Oct. 4 were Form I. A female captured in early April when she was nearly a year old was carrying eggs.

The largest longpincered crayfish known to me were from Table Rock Lake, suggesting that the growth potential of this species may be greater in large impoundments than in Ozark streams.

Importance

This species is captured for human consumption in Table Rock Lake. Because of its rapid growth in ponds and large size, the longpincered crayfish may be of potential value in aquaculture.

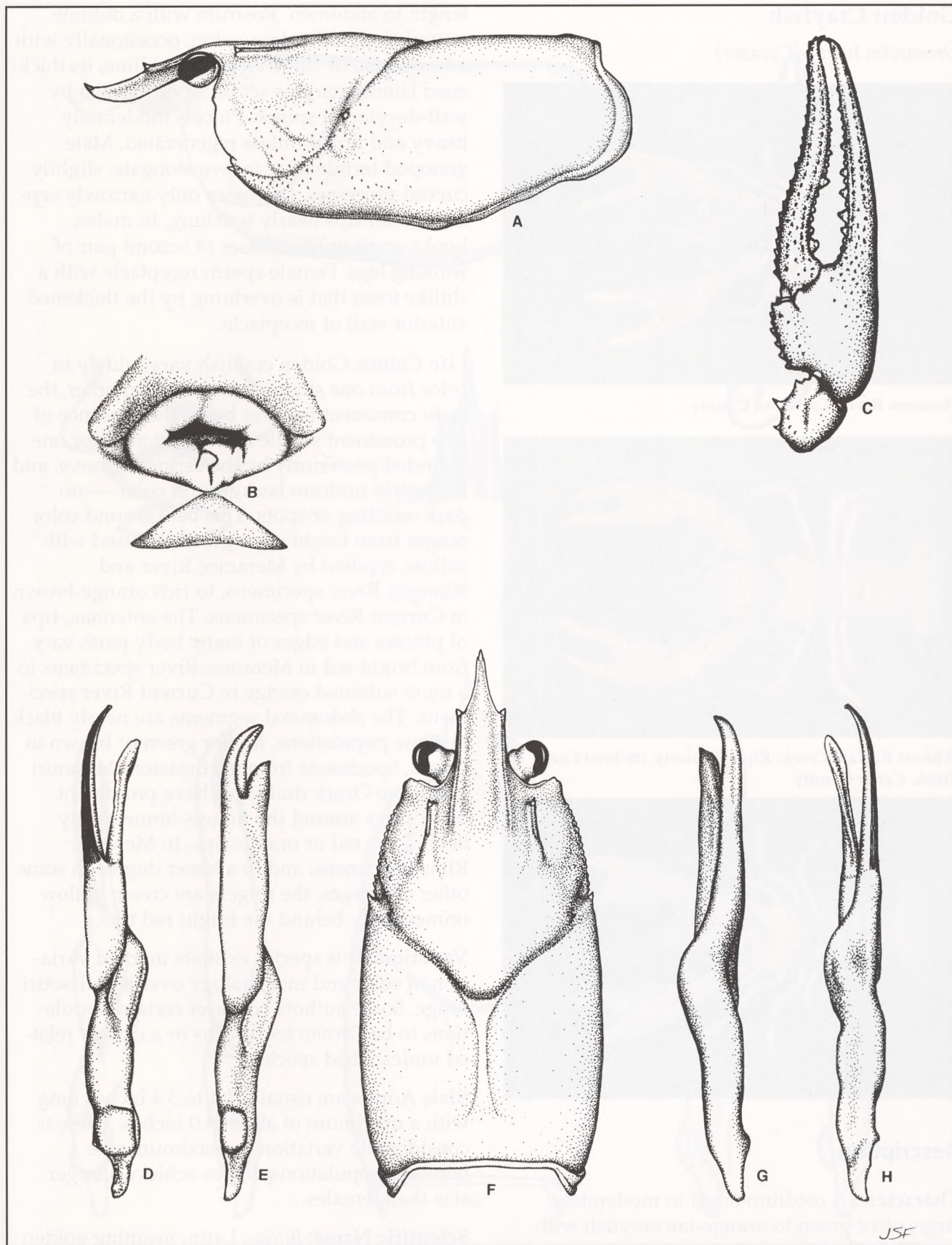
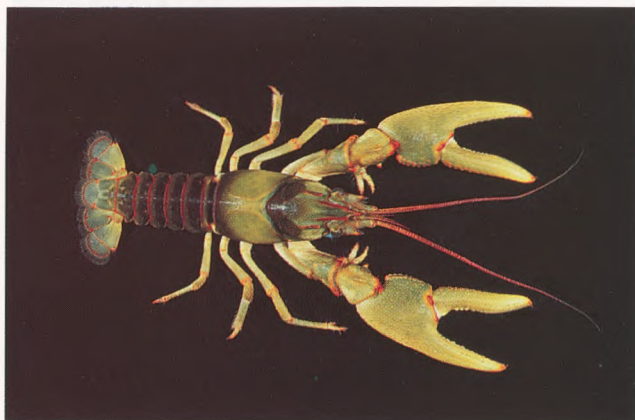


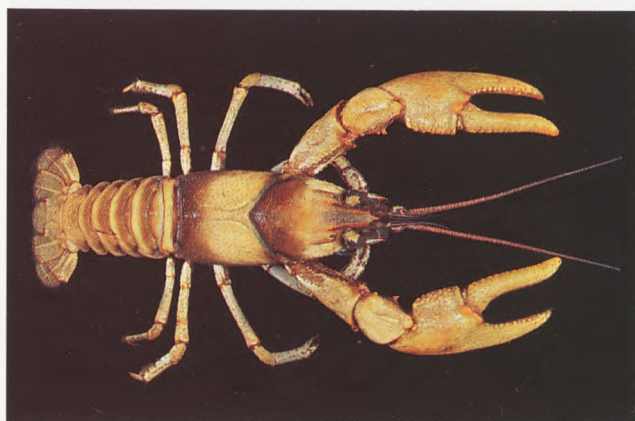
Plate 15. - *Orconectes longidigitus*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

Golden Crayfish

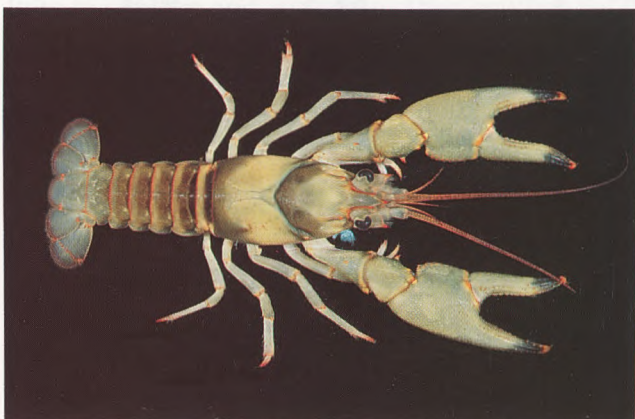
Orconectes luteus (Creaser)



Meramec River, Crawford County



(Above) Buffalo Creek, Ripley County. (Below) Cedar Creek, Cedar County



Description

Characters: A medium-sized to moderately large, olive-green to orange-tan crayfish with two dark saddle marks, one at posterior margin of head and the other at posterior margin of carapace. Carapace approximately equal in

length to abdomen. Rostrum with a definite central troughlike depression, occasionally with a low carina or ridge along its midline, its thickened lateral margins set off from acumen by well-developed spines. Pincers moderately heavy and broad unless regenerated. Male gonopod terminating in two elongate, slightly curved processes. Processes only narrowly separate, their tips nearly touching. In males, hooks occur only on bases of second pair of walking legs. Female sperm receptacle with a slitlike fossa that is overhung by the thickened anterior wall of receptacle.

Life Colors: Golden crayfish vary widely in color from one stream drainage to another, the most consistent features being the presence of two prominent saddle marks, the anterior one bounded posteriorly by the cervical groove, and the nearly uniform background color — no dark mottling or spots. This background color ranges from bright olive-green suffused with yellow, typified by Meramec River and Niangua River specimens, to rich orange-brown in Current River specimens. The antennae, tips of pincers and edges of many body parts vary from bright red in Meramec River specimens to a more subdued orange in Current River specimens. The abdominal segments are nearly black in some populations, lighter green or brown in others. Specimens from northeastern Missouri and some Ozark drainages have prominent black rings around the fingers immediately behind the red or orange tips. In Meramec River specimens, and to a lesser degree in some other drainages, the fingers are cream-yellow immediately behind the bright red tips.

Variation: This species exhibits marked variation in color and morphology over its Missouri range. Some authors consider certain populations to be *Orconectes rusticus* or a closely related undescribed species.^{46,66,73}

Size: Adults are usually 1.4 to 3.4 inches long with a maximum of about 4.0 inches. There is considerable variation in maximum size between populations. Males achieve a larger size than females.

Scientific Name: *luteus*, Latin, meaning golden yellow.

Most Like: Saddlebacked crayfish (*O. medius*),

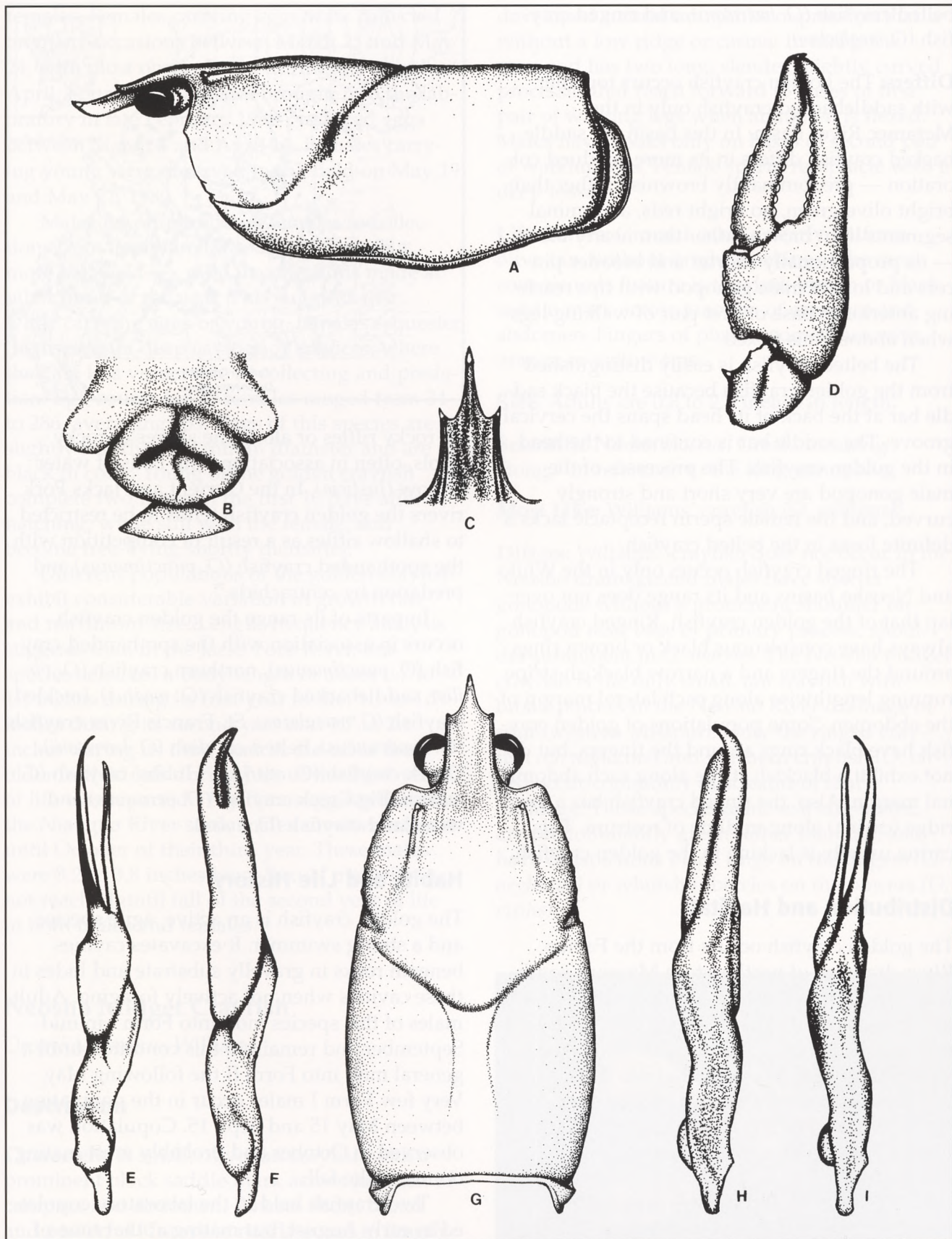


Plate 16. - *Orconectes luteus*. A, lateral view of carapace; B, female sperm receptacle; C, rostrum with carina; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

belted crayfish (*O. harrisoni*), and ringed crayfish (*O. neglectus*).

Differs: The golden crayfish occurs together with saddlebacked crayfish only in the Meramec River Basin. In this basin the saddlebacked crayfish differs in its more subdued coloration — predominantly brownish rather than bright olive-green, no bright reds, abdominal segments light brown rather than nearly black — its proportionally shorter and broader pincers and longer male gonopod with tips reaching anterior to base of first pair of walking legs when abdomen is flexed.

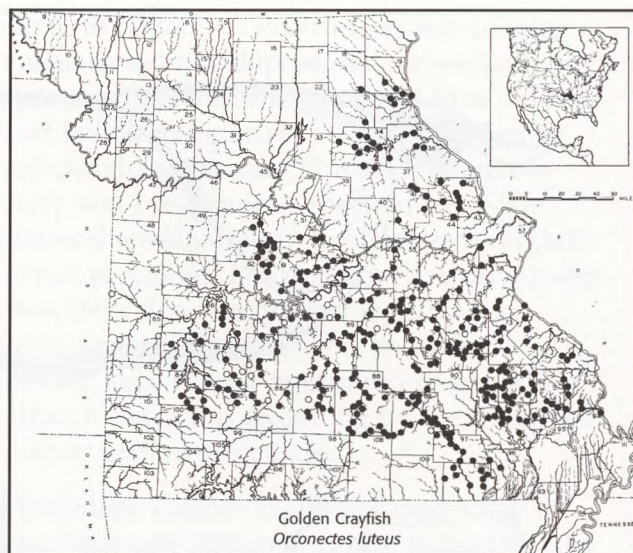
The belted crayfish is easily distinguished from the golden crayfish because the black saddle bar at the back of its head spans the cervical groove. The saddle bar is confined to the head in the golden crayfish. The processes of the male gonopod are very short and strongly curved, and the female sperm receptacle lacks a definite fossa in the belted crayfish.

The ringed crayfish occurs only in the White and Neosho basins and its range does not overlap that of the golden crayfish. Ringed crayfish always have conspicuous black or brown rings around the fingers and a narrow blackish stripe running lengthwise along each lateral margin of the abdomen. Some populations of golden crayfish have black rings around the fingers, but do not exhibit a blackish stripe along each abdominal margin. Also, the ringed crayfish has a low ridge (carina) along midline of rostrum. This carina usually is lacking in the golden crayfish.

Distribution and Habitat

The golden crayfish occurs from the Fabius River drainage of northeastern Missouri southward through the eastern Ozarks to the Current River drainage of Ripley County and westward through the Meramec, Gasconade and Osage stream drainages to eastern Kansas. This is one of the most common crayfish species over much of the Ozarks, but it is absent from the Black, Eleven Point, White and Neosho stream drainages.

O. luteus occurs in streams ranging in size from headwater creeks to large rivers. The common denominators of all these streams are the presence of rocky and gravelly substrates and relatively permanent flow. It is generally found



on rocky riffles or along the shores of rocky pools, often in association with beds of water willow (*Justicia*). In the Current and Jacks Fork rivers the golden crayfish tends to be restricted to shallow riffles as a result of competition with the spothanded crayfish (*O. punctimanus*) and predation by centrachids.⁷⁷

In parts of its range the golden crayfish occurs in association with the spothanded crayfish (*O. punctimanus*), northern crayfish (*O. virilis*), saddlebacked crayfish (*O. medius*), freckled crayfish (*C. maculatus*), St. Francis River crayfish (*O. quadruncus*), belted crayfish (*O. harrisoni*), Ozark crayfish (*O. ozarkae*), Hubbs' crayfish (*C. hubbsi*), Big Creek crayfish (*O. peruncus*) and woodland crayfish (*O. hylas*).

Habits and Life History

The golden crayfish is an active, agile species and a strong swimmer. It excavates cavities beneath rocks in gravelly substrate and hides in these cavities when not actively foraging. Adult males of this species molt into Form I in mid-September and remain in this condition until a general molt into Form II the following May. Very few Form I males occur in the population between May 15 and Sept. 15. Copulation was observed in October and probably most mating occurs in the fall.

Two crayfish held in the laboratory copulated in early August, but mating at that time of year would be limited by the scarcity of males in breeding condition. Sperm plugs were not observed in the sperm receptacles of mated

females. Females carrying eggs were collected on many occasions between March 25 and May 24, with most observations during the month of April. Four of five females brought into the laboratory in late February 1988 produced eggs between March 8 and April 14. Females carrying young were observed in the field on May 19 and May 21, 1980.

Males far outnumbered females in collections from late March through May, with a more balanced sex ratio in collections made at other times of the year. This suggests that, while carrying eggs or young, females sequester themselves in deep cavities or crevices, where they are less vulnerable to collecting and predation. Egg counts for 28 females ranged from 34 to 286, averaging 139. Eggs of this species are slightly less than 2.0 mm in diameter and are black in color. Young of the golden crayfish complete two molts in the first 10 days after hatching, while still with the female, and become free-living shortly thereafter.⁶¹

Different populations of the golden crayfish exhibit considerable variation in growth rate and maximum size. Length-frequency analysis suggests that, in the Jacks Fork River, this species achieves a body length of about 0.7 to 1.1 inches during its first year of life, 1.1 to 1.7 inches during its second year and 1.7 to 2.1 inches during its third year. A die-off of the older individuals during July of the third year of life was reported.⁷⁷ My data suggests that in the Niangua River some males survived at least until October of their third year. These males were 3.2 to 3.8 inches long. Sexual maturity is not reached until fall of the second year of life in both males and females.

Neosho Midget Crayfish

Orconectes macrus Williams

Description

Characters: A small, olive-tan crayfish with a prominent black saddle mark across junction of carapace and abdomen. Pincers short, broad and powerful. Carapace nearly equal in length to abdomen. Rostrum narrow, its conspicuously thickened lateral margins set off from acumen by well-developed spines. Rostrum with a well-

developed central troughlike depression that is without a low ridge or carina. In males the gonopod has two long, slender, slightly curved processes that reach forward to bases of first pair of walking legs when abdomen is flexed. Males have hooks only on bases of second pair of walking legs. Female sperm receptacle with a deep fossa.

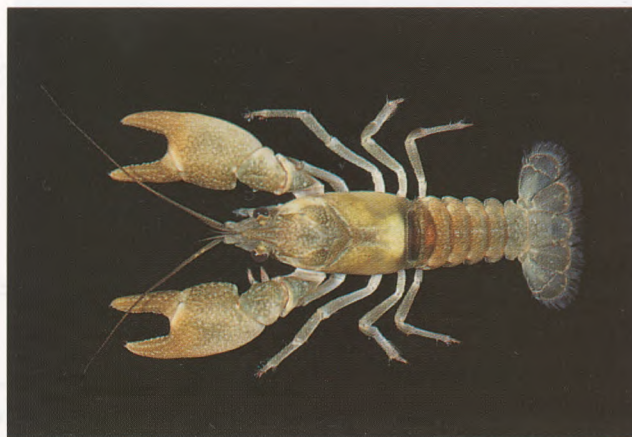
Life Colors: Ground color a nearly uniform olive-tan, without bright markings. The most conspicuous feature is the dark brown or black saddle mark across junction of carapace and abdomen. Fingers of pincers sometimes with orange or yellow tips.

Size: Adults are 0.8 to 2.0 inches in length.

Scientific Name: *macrus*, Greek, meaning "long," in reference to the long gonopods.

Most Like: Williams' crayfish (*O. williamsi*)

Differs: Williams' crayfish does not occur in the Neosho drainage and males have shorter gonopods without a prominent shoulder on gonopod near base of primary process; shoulder prominent in *O. macrus*. The Neosho midget crayfish is the only small, tan crayfish with broad pincers in the Neosho River drainage of southwestern Missouri. Only the ringed crayfish (*O. neglectus*) and northern crayfish (*O. virilis*) occur commonly in streams of that drainage. Those species achieve a larger size, are predominantly green rather than tan, and have conspicuous black rings on the fingers (*O. neglectus*) or whitish tubercles on the pincers (*O. virilis*).



Indian Creek, Newton County

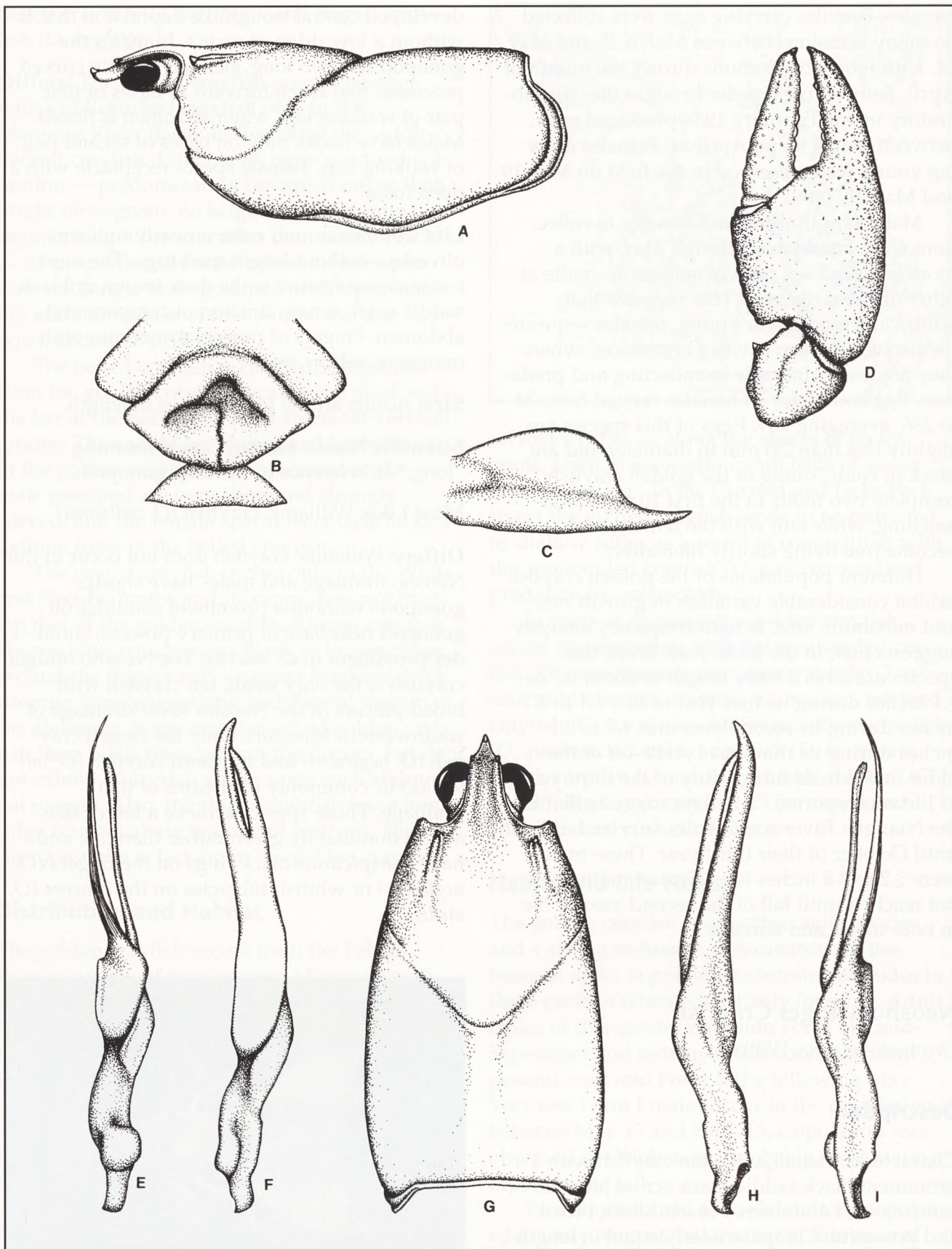
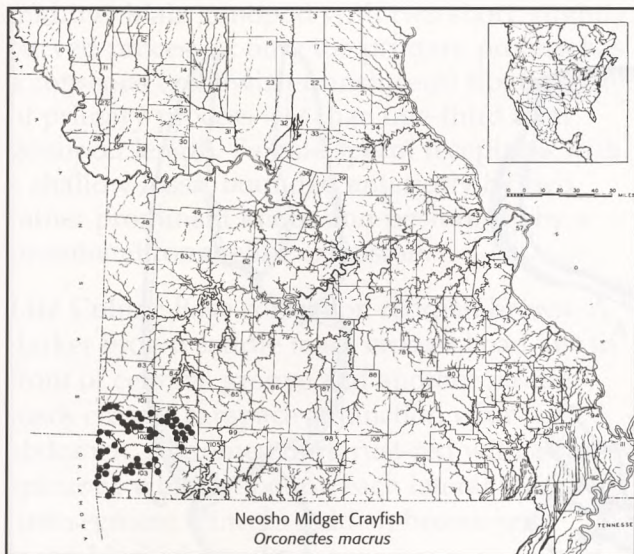


Plate 17. - *Orconectes macrus*. A, lateral view of carapace; B, female sperm receptacle; C, antennal scale; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.



Distribution and Habitat

This species occurs in the Neosho (Arkansas) stream drainage of southwestern Missouri and northwestern Arkansas and probably in adjacent counties of Kansas and Oklahoma. In Missouri it is a common crayfish in most streams of the Neosho drainage except for North Fork of Spring River in Jasper and Barton counties.

The Neosho midget crayfish inhabits clear, permanent-flowing Ozark streams over a firm gravelly or rocky substrate in swift, shallow water. It digs short tunnels in areas of small gravel or beneath rubble or boulders.

The only crayfish species found in association with the Neosho midget crayfish in Missouri were the ringed crayfish (*O. n. neglectus*) and the northern crayfish (*O. virilis*). The ringed crayfish occurred in all collections in which *O. macrus* was recorded, and more than half of these collections also included the northern crayfish.

Habits and Life History

The Neosho midget crayfish is a sedentary species that spends much of its time in cavities beneath rocks or in tunnels that it digs in gravelly substrate. It is not an agile or strong swimmer, and seldom takes evasive action when attempts are made to capture it by hand. Its habits and behavior are more like those of a *Cambarus* than of most other *Orconectes* that occur in Missouri.

Males molt into Form I in mid-September and remain in this condition through winter

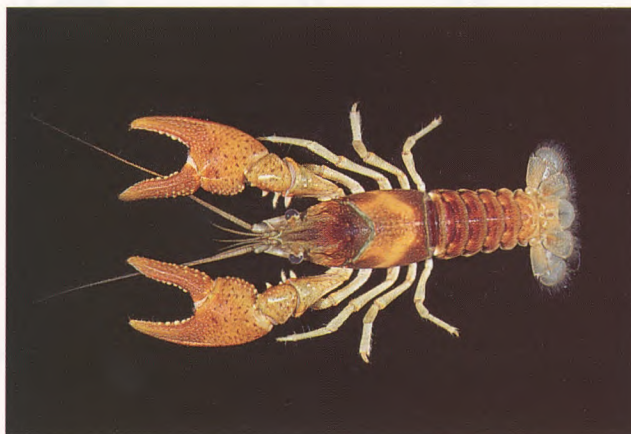
and early spring. In late March or early April they molt into Form II, remaining in that condition through the summer. Breeding was not observed, but the molting pattern outlined above suggests a fall and early winter breeding season, as in most Ozark crayfishes.

Approximately 25 percent of females collected in late March were carrying eggs. Only four females were collected during April, and males outnumbered females 10:1 in the collections. I suspect that most females were bearing eggs or young in that month and were sequestered in burrows where they were inaccessible to collection. Egg counts of nine females ranged from 23 to 63, averaging 39. The eggs were black and about 2.0 mm in diameter.

In my collections, the smallest Neosho midget crayfish collected in early spring (March) were about 0.8 inches in length and included females with eggs and Form I males. This suggests that sexual maturity is reached during the first year of life. Although the largest individuals collected were males, the sexes were, on average, of similar size.

Mammoth Spring Crayfish

Orconectes marchandi Hobbs



Spring River, Oregon County

Description

Characters: A medium-sized reddish-brown crayfish with many blackish specks on its rather broad, powerful pincers. Carapace slightly longer than abdomen. Rostrum with a definite central troughlike depression, its thickened lateral margins set off from acumen by well-developed spines. Areola present along carapace

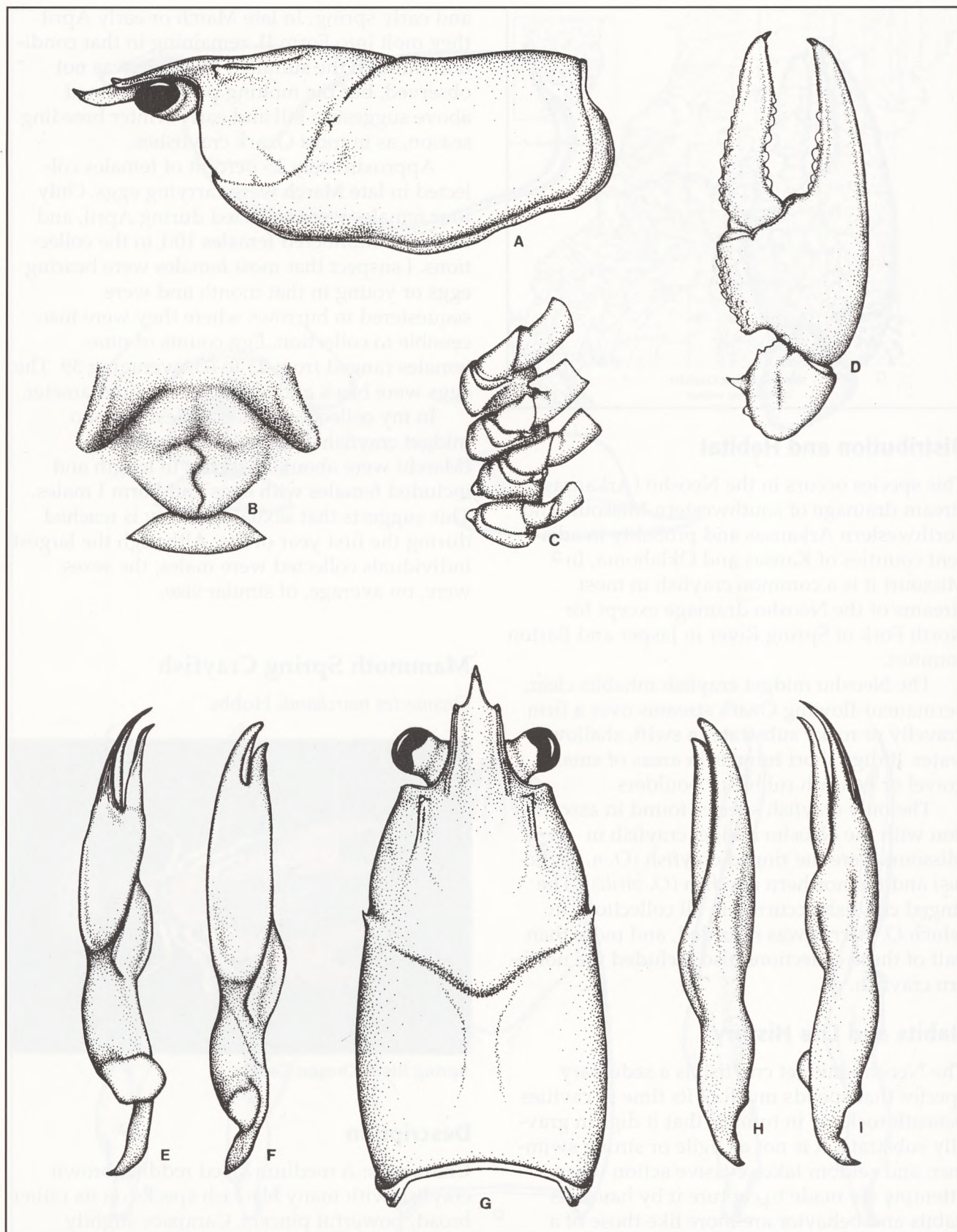


Plate 18. - *Orconectes marchandi*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

midline. Male gonopod with two short, slightly curved processes; only the primary process has a corneous (yellowish-translucent) tip. Length of primary process less than one-third total gonopod length. Female sperm receptacle with a shallow fossa, bounded anteriorly by two rather prominent knobs and posteriorly by a prominent tonguelike extension.

Life Colors: Base coloration reddish-brown. A darker brown saddle mark crosses head just in front of cervical groove and another saddle mark crosses carapace at junction with abdomen. Abdomen dark rust-red with a conspicuous whitish spot on each lateral margin of first segment. Pincers reddish-brown with many blackish specks.

Size: Adults are about 1.2 to 2.2 inches long.

Scientific Name: Named in honor of Lewis J. Marchand.

Most Like: Of crayfish within its range, the Mammoth Spring crayfish bears a close resemblance only to the Ozark crayfish (*O. ozarkae*).

Differs: The Ozark crayfish is lighter tan and less reddish in color. Males of this species are easily separated from the Mammoth Spring crayfish by the long, slender gonopod processes, the length of the primary process much more than one-third total length of gonopod.

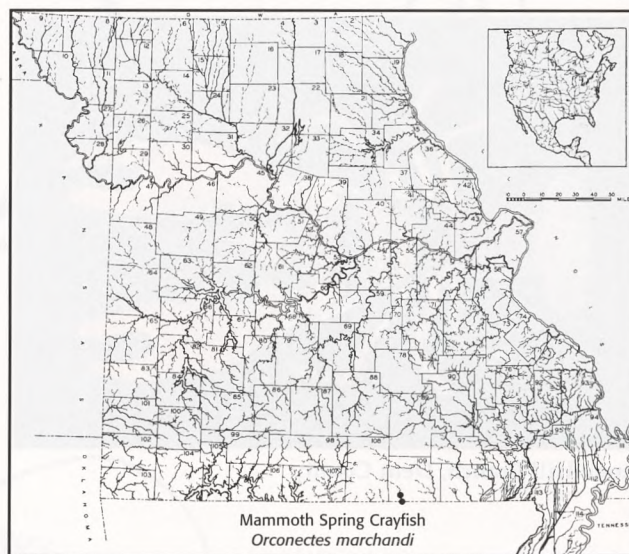
Distribution and Habitat

The Mammoth Spring crayfish has a very localized distribution in the Spring River and its tributaries in Sharp and Lawrence counties, Arkansas; and Oregon County, Missouri. In Oregon County it has been collected only from a short stretch of the Warm Fork of Spring River near Thayer.

Warm Fork is a medium-sized, clear Ozark stream with well-defined riffles and runs. The Mammoth Spring crayfish occurs on riffles over gravel or rubble substrate.

This species was found in association with the Ozark crayfish (*O. ozarkae*), spothanded crayfish (*O. punctimanus*) and Hubbs' crayfish (*C. hubbsi*). In Arkansas it has been reported in association with the coldwater crayfish (*O. eupunctus*). In my collections from Warm Fork, the Mammoth Spring crayfish was the most

common crayfish or was second in abundance to the spot-handed crayfish.



Habits and Life History

My data suggest that the Mammoth Spring crayfish breeds in early fall and reproduces in spring, as is typical of stream crayfish in the Ozarks. Four of 27 females collected Sept. 18, 1984 had sperm plugs, suggesting that breeding was just getting underway. A larger proportion (12 of 15) collected Nov. 13, 1985 had sperm plugs, indicating that most mature females probably had mated. Three of four females collected March 22, 1988 were carrying eggs. These eggs were yellow or dark orange and about 1.8 mm in diameter. The number of eggs carried by these females ranged from 26 to 112, averaging 71. Males far outnumbered females in this collection, suggesting that females become secretive when carrying eggs or young, and, as a result, are difficult to collect.

Saddlebacked Crayfish

Orconectes medius (Faxon)



Stone Hill Branch, Dent County

Description

Characters: An olive-tan, medium-sized crayfish with broad, powerful pincers and two conspicuous blackish saddle marks across body, one anterior to cervical groove and the other across back of carapace. Carapace shorter than abdomen. Rostrum moderately broad, with a central troughlike depression; depression usually with a low ridge or carina along its midline. Conspicuously thickened lateral margins of rostrum set off from acumen by weakly developed spines or tubercles.

Male gonopod terminating in two exceptionally long, slightly curved processes that reach forward to bases of first pair of walking legs when abdomen is flexed. Prominent shoulder present on male gonopod at base of primary process. Gonopod processes only narrowly separate at their tips, the secondary process curving in direction of primary process. Female sperm receptacle with a slitlike fossa that is overhung by thickened anterior wall of receptacle.

Life Colors: Background coloration a more or less uniform olive-tan. Two prominent blackish saddle marks cross the body, one on head and the other on carapace at junction with abdomen. Abdomen reddish-brown with a row of small spots running lengthwise along each lateral margin. Pincers uniform reddish-tan without mottling or spots.

Size: Adults are about 1.1 to 2.6 inches long.

Scientific Name: *medius*, Latin, meaning "middle."

Most Like: Golden crayfish (*O. luteus*), belted crayfish (*O. harrisoni*) and woodland crayfish (*O. hylas*).

Differs: Where their ranges overlap, the golden crayfish is distinguished from the saddlebacked crayfish by its more brilliant coloration — bright green trimmed with red, blackish abdominal segments, proportionally longer and narrower pincers, and shorter male gonopods.

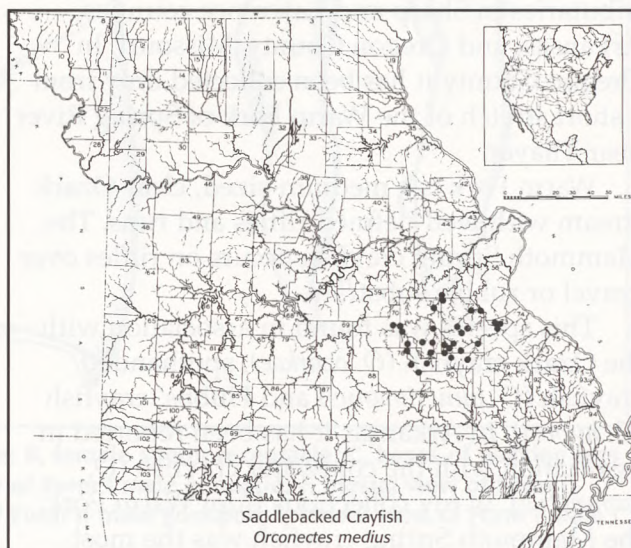
The belted crayfish differs in that the front saddle mark spans the cervical groove, and the processes of the male gonopod are very short and strongly curved.

The woodland crayfish resembles the saddlebacked crayfish primarily in the long, slender processes of the male gonopod. In the woodland crayfish the midpoint of the secondary process of the male gonopod is about as thick as the primary process; it is not as thick in the saddlebacked crayfish; the anterior wall of the female sperm receptacle is thin and does not overhang the fossa in the woodland crayfish.

Distribution and Habitat

The saddlebacked crayfish is confined to the Ozark Region of Missouri where it occurs only in the Big and Meramec stream drainages. It does not occur in the adjoining Bourbeuse drainage. It is the most abundant crayfish in many small creeks within its range.

This crayfish occurs abundantly in small to medium-sized creeks having clear, permanent



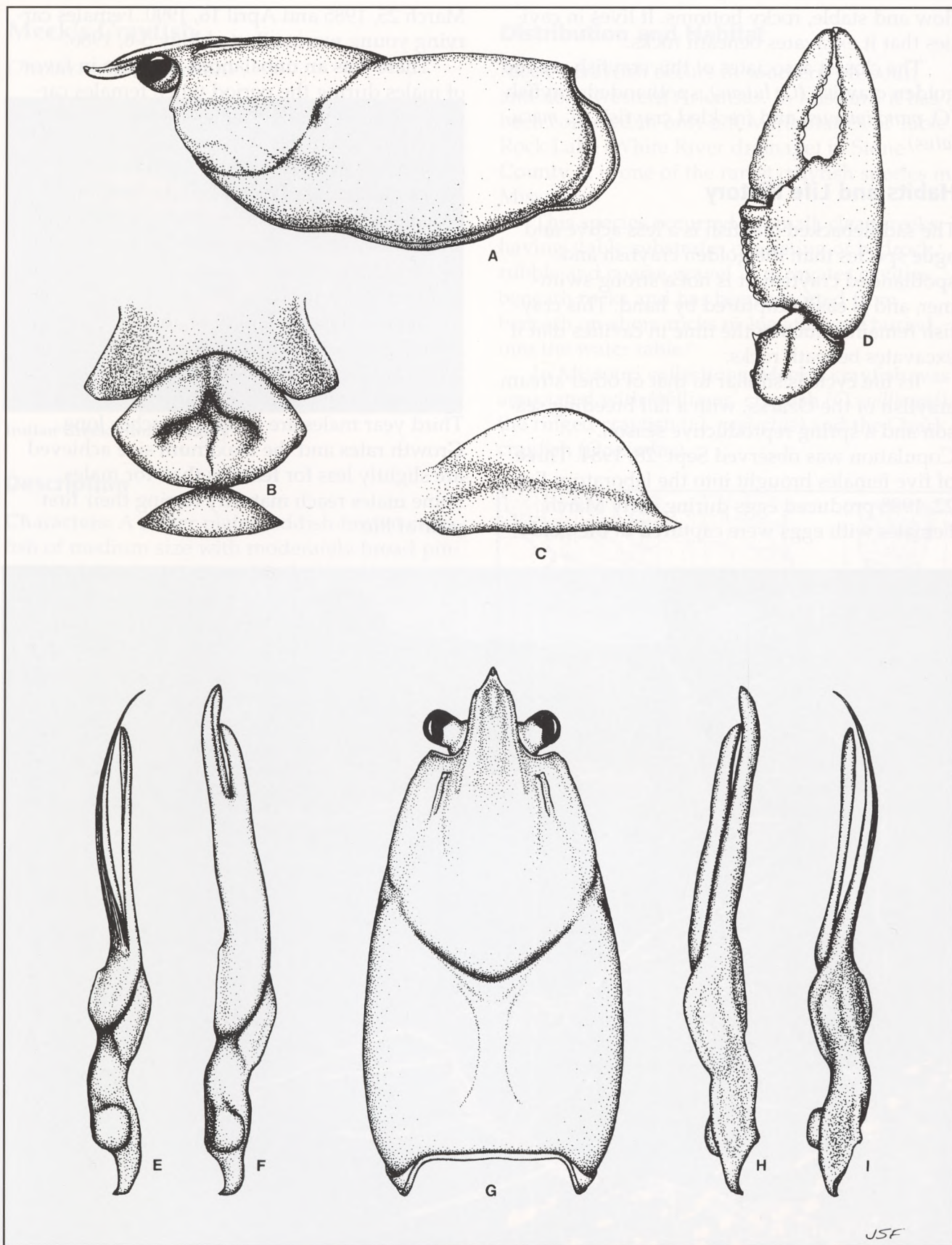


Plate 19. - *Orconectes medius*. A, lateral view of carapace; B, female sperm receptacle; C, antennal scale; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

flow and stable, rocky bottoms. It lives in cavities that it excavates beneath rocks.

The closest associates of this crayfish are the golden crayfish (*O. luteus*), spothanded crayfish (*O. punctimanus*) and freckled crayfish (*C. maculatus*).

Habits and Life History

The saddlebacked crayfish is a less active and agile species than the golden crayfish and spothanded crayfish. It is not a strong swimmer, and is easily captured by hand. This crayfish remains much of the time in cavities that it excavates beneath rocks.

Its life cycle is similar to that of other stream crayfish of the Ozarks, with a fall breeding season and a spring reproductive season. Copulation was observed Sept. 28, 1984. Three of five females brought into the laboratory Feb. 22, 1988 produced eggs during early March. Females with eggs were captured in the field

March 25, 1985 and April 16, 1990. Females carrying young were collected May 5-6, 1986.

There was an unbalanced sex ratio in favor of males during the period when females carried eggs and young, suggesting that most reproducing females were in deep cavities or crevices where they were difficult to collect. Males molted into Form I by late September, remained in this condition through the winter, and underwent a general molt back to Form II by early May. All of 118 males captured in June were in the Form II condition.

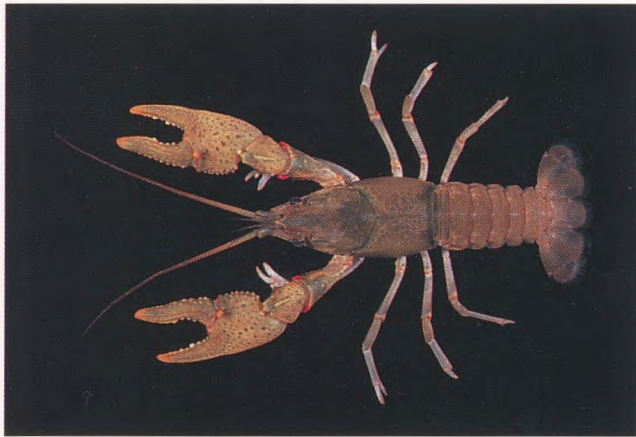
Males achieve a length of about 0.8 to 1.4 inches during their first year of life and 1.5 to 2.1 inches during their second year. A few males may complete three growing seasons. Third year males are about 2.3 inches long. Growth rates and the maximum size achieved are slightly less for females than for males. Some males reach maturity during their first year of life.



Meramec River, Franklin County; habitat of the saddlebacked crayfish, *O. medius*. The freckled crayfish, *C. maculatus*; golden crayfish, *O. luteus*; and spothanded crayfish, *O. punctimanus*, also occur here.

Meek's Crayfish

Orconectes meeki (Faxon)



Indian Creek, Stone County

Description

Characters: A rather plain, reddish-brown crayfish of medium size with moderately broad pincers sprinkled with many blackish spots. A rather prominent dark spot is present near tubercle at base of moveable finger. Carapace a little shorter than abdomen. Areola well-developed. Male gonopod terminating in two elongate, rather strongly curved processes; gonopod processes both curving in same direction and widely separate near their tips. Female sperm receptacle with a prominent fossa and without a tonguelike posterior extension.

Life Colors: Ground color light reddish-brown. Two inconspicuous dark saddle marks across carapace; anterior mark on head just in front of cervical groove. Pincers light tan with blackish specks and a definite spot near base of moveable finger. Fingers with bright orange tips.

Size: Adults are about 1.7 to 2.2 inches in length.

Most Like: Ozark crayfish (*O. ozarkae*), Williams' crayfish (*O. williamsi*).

Differs: In the Ozark crayfish the processes of the gonopod are much longer, reaching far forward of base of first pair of walking legs when abdomen is flexed; the female sperm receptacle has a triangular posterior extension.

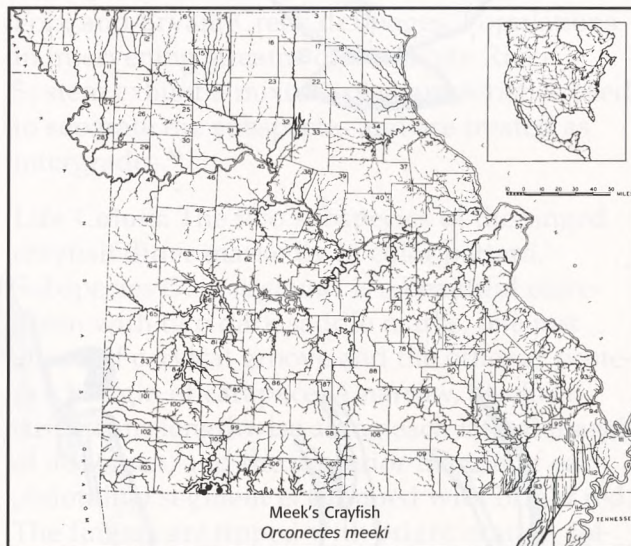
Williams' crayfish differs in having a pale, vase-shaped pattern on the carapace. Secondary process of male gonopod is nearly straight and only slightly separate from primary process.

Distribution and Habitat

Meek's crayfish occurs in southern Missouri and northwestern Arkansas. In Missouri it has been collected in only a few tributaries of Table Rock Lake (White River drainage) in Stone County. It is one of the rarest crayfish species in Missouri.

This species occurred in small, clear creeks having stable substrates consisting of bedrock, rubble and coarse gravel. It excavates cavities beneath rocks and has been reported from beneath on-shore rocks or logs that are buried into the water table.⁶

In Missouri collections, Meek's crayfish was associated with Williams' crayfish (*O. williamsi*), the ringed crayfish (*O. neglectus*) and the Ozark crayfish (*O. ozarkae*).



Habits and Life History

Only nine specimens of Meek's crayfish occurred in my collections. These consisted of both Form I and Form II males, as well as females, collected in April and October. On April 8, 1988 a large, freshly molted Form II male was found beneath a rock along with its molted skin, which was also Form II. A freshly molted female also was collected on that date.

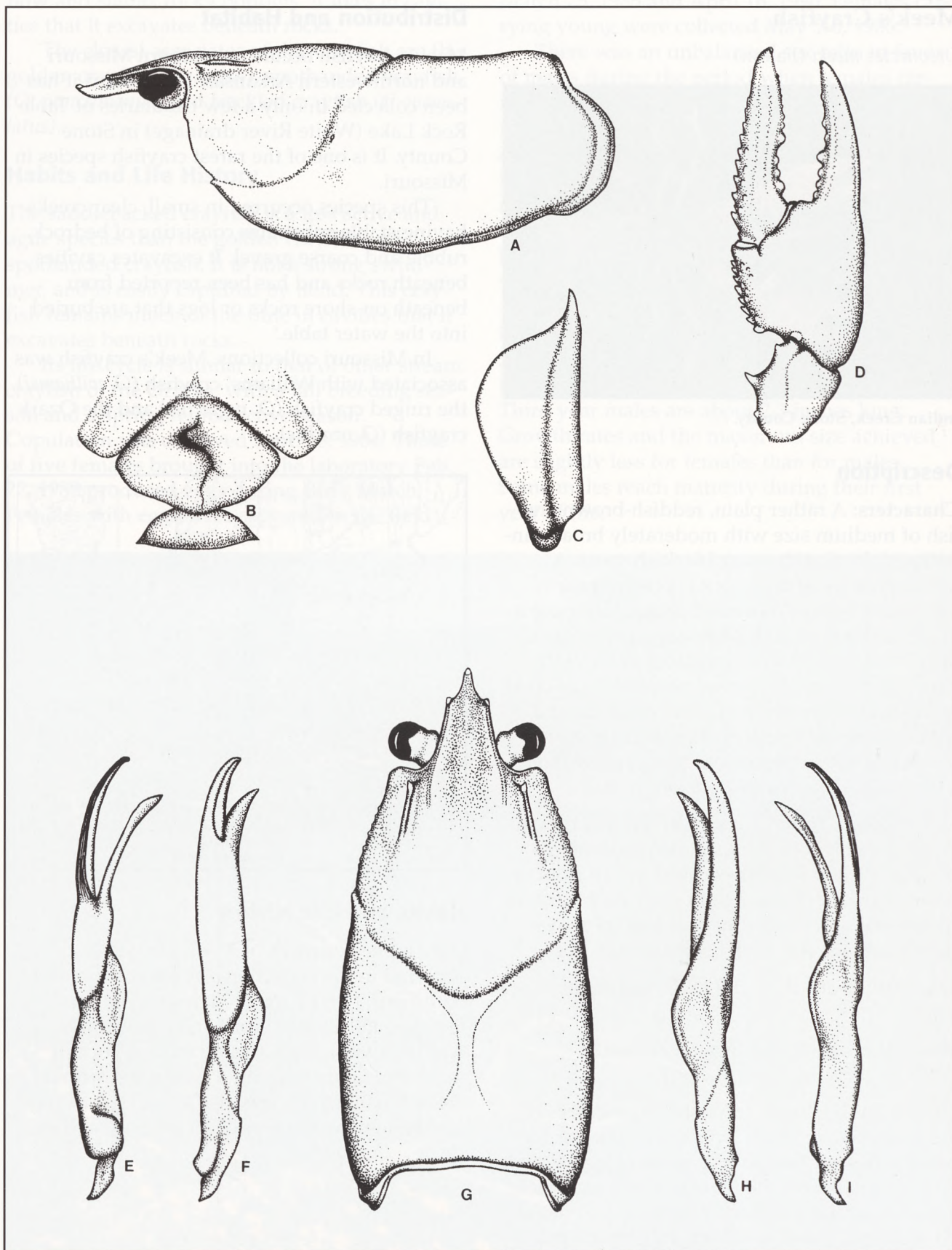
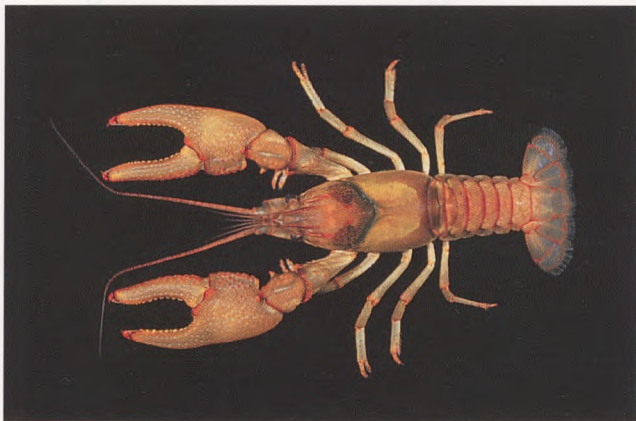


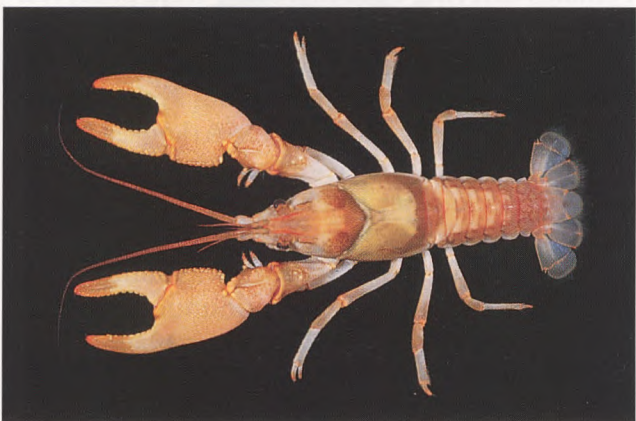
Plate 20. - *Orconects meeki*. A, lateral view of carapace; B, female sperm receptacle; C, antennal scale; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

Ringed Crayfish

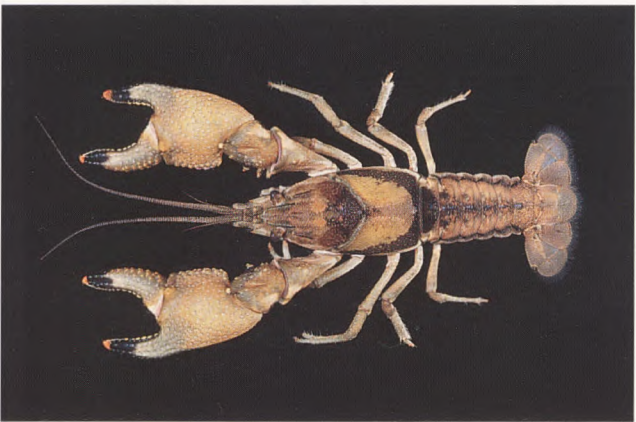
Orconectes neglectus (Faxon)



O. n. neglectus; Sugar Creek, Barry County



(Above) *O. n. chaenodactylus*; Bryant Creek, Ozark County. (Below) Intergrade between *O. n. neglectus* and *O. n. chaenodactylus*; James River, Christian County



Description

Characters: A medium-sized, olive-green to reddish-tan crayfish with prominent black or brown rings around the pincers near their tips. Pincers often broad and heavy, especially in males, with a wide space between fingers when

they are closed. Rostrum with a troughlike central depression; depression usually with a low ridge or carina running lengthwise along its midline. Thickened lateral margins of rostrum narrowing abruptly into a well-defined acumen.

Male gonopod terminates in two elongate, slightly curved processes. The processes curve toward each other and their tips nearly touch or are separated only by a very narrow space. Female sperm receptacle with a slitlike fossa that dips under overhanging anterior margin of receptacle.

Variation: Two subspecies of the ringed crayfish have been recognized and both occur in Missouri. The nominate subspecies (*O. n. neglectus*) occurs in the Spring (Neosho) River drainage while the other subspecies (*O. n. chaenodactylus* Williams) occurs in the North Fork and Bryant Creek drainages. Populations in intervening streams of the White River System exhibit a mixture of characteristics used to separate the subspecies and are treated as intergrades.⁸⁸

Life Colors: The two subspecies of the ringed crayfish differ markedly in color pattern. Subspecies *O. n. neglectus* is a beautiful olive-green with two dark saddle marks, one just ahead of cervical groove and the other at posterior margin of carapace. A narrow, blackish stripe runs lengthwise along each lateral margin of abdomen, and the posterior margin of each abdominal segment is trimmed with bright red. The fingers are tipped with bright orange, followed in most individuals by a prominent black ring.

Subspecies *O. n. chaenodactylus* is reddish-tan with a broad brownish stripe running lengthwise along each lateral margin of abdomen. These stripes broaden and converge posteriorly, forming a characteristic V-shaped pattern. The fingers have broad, brown rings near their tips, followed by pale yellow zones toward their bases. Intergrading populations of ringed crayfish exhibit various combinations of the color pattern of the two subspecies, the only consistent feature being black or brown rings on the fingers.

Size: Adults are about 1.2 to 3.8 inches long.

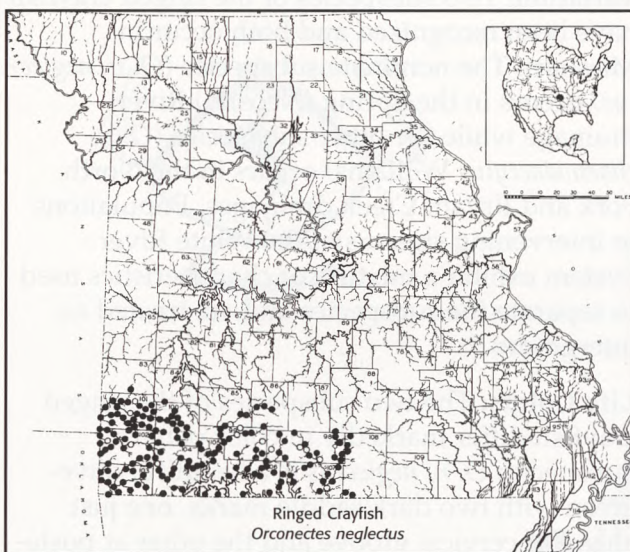
Scientific Name: *neglectus*, Latin, meaning "neglected" or "not chosen;" *chaenodactylus*,

Greek, meaning "gape-fingered."

Most Like: Golden crayfish (*O. luteus*).

Differs: Only a few populations of the golden crayfish have black rings on the fingers of the pincers. The golden crayfish never has black or brown lengthwise stripes on lateral margins of abdomen, and usually lacks a carina on rostrum. The golden crayfish and ringed crayfish are not known to occur in the same streams.

Distribution and Habitat



This species occurs in the southwestern Ozark region of Missouri, Arkansas and Oklahoma, with isolated populations in central Kansas, southwestern Nebraska and northeastern Colorado. In Missouri, the ringed crayfish occurs from the North Fork of White River in Howell County, westward through the White and Spring (Neosho) River basins. Within its range it is the most abundant and generally distributed stream crayfish.

The ringed crayfish occurs in clear, rocky permanent-flowing streams ranging in size from small creeks to large rivers. It occurs in rocky riffles and shallow pools having sufficient current to keep the bottom largely free of silt.

In the White River Basin this species is most closely associated with the Ozark crayfish (*O. ozarkae*), the longpincered crayfish (*O. longidigitus*) and Williams' crayfish (*O. williamsi*). In the Spring (Neosho) River Basin it is associated with the Neosho midget crayfish (*O. macrus*) and the northern crayfish (*O. virilis*).

Habits and Life History

The ringed crayfish excavates cavities in the gravel beneath rocks and comes out at night to forage on algae and detritus. Breeding occurs from October to April and eggs are laid in the spring.⁷⁶ Females with eggs occurred in Missouri collections on the following dates: March 27, 1985; April 2, 1987; April 15, 1986; May 13, 1986; and June 20, 1985. I collected females carrying young May 13-14, 1986.

It appears that the peak of egg production occurs in April in warmwater streams, but may be somewhat later in cooler waters. I collected a female with eggs June 20, 1985 from a spring-fed stream, at a time when females from warmer streams were no longer carrying eggs. Females carrying eggs or young were observed in early June in a stream emerging from a cave, at a time when no females with eggs were found in warmer streams.³⁴ Young appeared in open water of Sylamore Creek, Arkansas in mid-May.⁷⁶ They dispersed from the female two to three weeks after hatching, when they had completed two molts.

Growth in Sylamore Creek was similar in males and females, and the minimum adult size of 2.2 inches was reached by November.⁷⁵ No growth occurred through the winter, and males molted to the nonbreeding condition in April or May. Females molted approximately two weeks after the young dispersed. Both sexes completed two or three more molts before the next fall breeding season.⁷⁴ Most individuals lived 2.5 years with the majority dying before the third year. However, a few lived as long as five years. I observed an extensive mortality among large Form I males in early April, 1987.

In my collections, 18 females ranging in size from 1.6 to 3.1 inches carried 54 to 505 eggs, averaging 245. These eggs were 1.6 to 2.0 mm in diameter and were bright yellow.

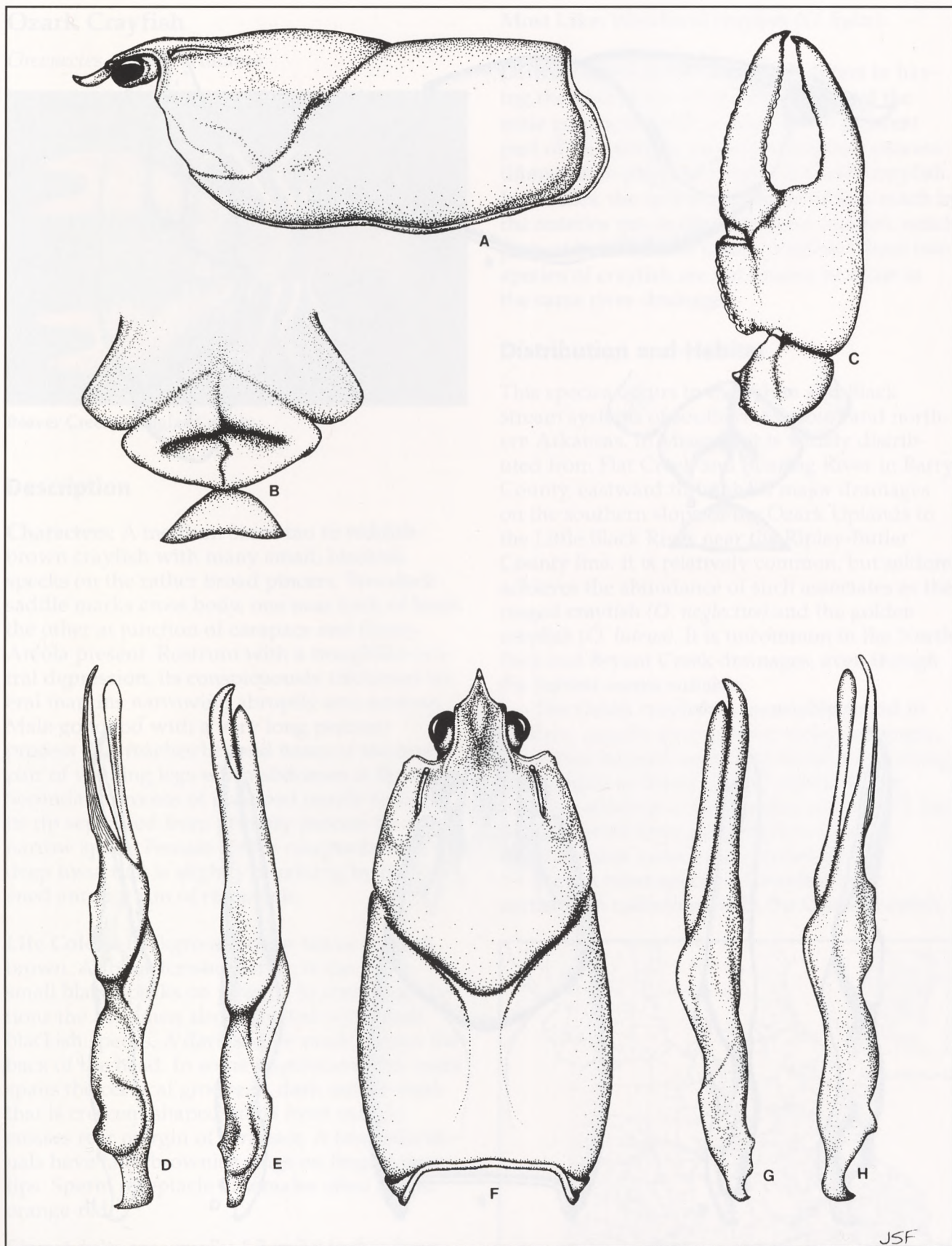


Plate 21. - *Orconectes neglectus chaenodactylus*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

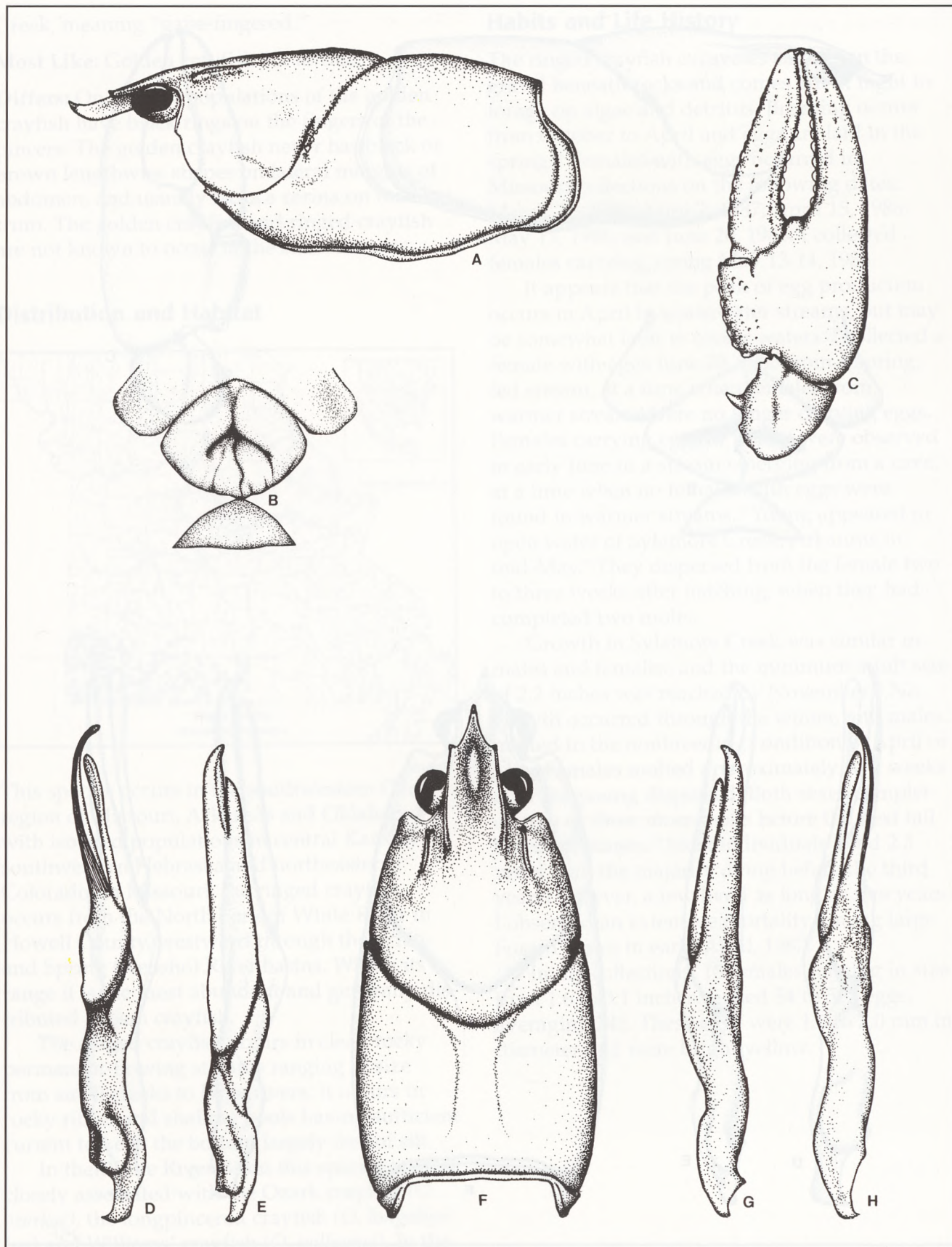
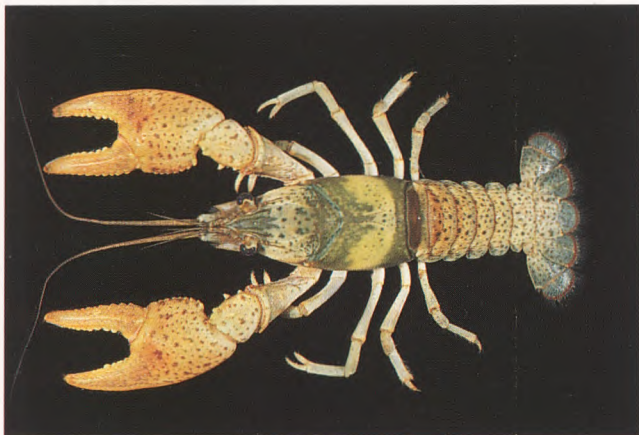


Plate 22. - *Orconectes neglectus neglectus*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod, H, lateral view of Form I male gonopod.

Ozark Crayfish

Orconectes ozarkae Williams



Beaver Creek, Douglas County

Description

Characters: A medium-sized tan to reddish-brown crayfish with many small, blackish specks on the rather broad pincers. Two dark saddle marks cross body, one near back of head, the other at junction of carapace and thorax. Areola present. Rostrum with a troughlike central depression, its conspicuously thickened lateral margins narrowing abruptly into acumen. Male gonopod with a very long primary process that reaches beyond bases of the first pair of walking legs when abdomen is flexed. Secondary process of gonopod nearly straight, its tip separated from primary process by only a narrow space. Female sperm receptacle with a deep fossa that is slightly overhung by thickened anterior rim of receptacle.

Life Colors: Background color tan or reddish brown. A characteristic feature is the many small black specks on pincers. In some populations the abdomen also is dusted with small blackish specks. A dark saddle mark crosses the back of the head. In some populations this mark spans the cervical groove. A dark saddle mark that is crescent-shaped on its front margin crosses rear margin of carapace. A few individuals have faint brownish rings on fingers near tips. Sperm receptacle of females often bright orange-red.

Size: Adults are usually 1.2 to 3.0 inches long.

Scientific Name: Named *ozarkae* because its distribution is limited to the Ozark Plateaus.

Most Like: Woodland crayfish (*O. hylas*).

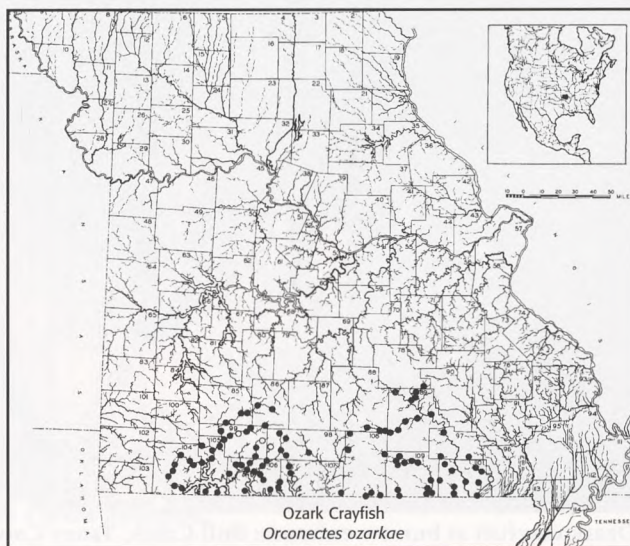
Differs: The woodland crayfish differs in having the base of the secondary process of the male gonopod about as thick as the adjacent part of the primary process; secondary process thinner than primary process in Ozark crayfish. In females, the sperm receptacle lacks a notch in the anterior rim in the woodland crayfish; notch present in females of Ozark crayfish. These two species of crayfish are not known to occur in the same river drainages.

Distribution and Habitat

This species occurs in the White and Black stream systems of southern Missouri and northern Arkansas. In Missouri it is widely distributed from Flat Creek and Roaring River in Barry County, eastward through all major drainages on the southern slope of the Ozark Uplands to the Little Black River near the Ripley-Butler County line. It is relatively common, but seldom achieves the abundance of such associates as the ringed crayfish (*O. neglectus*) and the golden crayfish (*O. luteus*). It is uncommon in the North Fork and Bryant Creek drainages, even though the habitat seems suitable.

The Ozark crayfish is invariably found in streams, usually over silt-free rocky substrates, in cavities beneath rocks and boulders, or along the margins of dense beds of water willow (*Justicia*) adjacent to swift riffles and runs. It has been reported from moist burrows under deeply-seated rocks in dry stream beds.⁸⁹

Eleven other species of crayfish have occurred in collections with the Ozark crayfish.



In the White River basin its closest associates were the ringed crayfish (*O. neglectus*) and the longpincered crayfish (*O. longidigitus*). In the Black River basin it was most closely associated with the spothanded crayfish (*O. punctimanus*), golden crayfish (*O. luteus*), Hubbs' crayfish (*C. hubbsi*), coldwater crayfish (*O. eupunctus*) and the Mammoth Spring crayfish (*O. marchandi*).

Habits and Life History

This species excavates cavities under rocks. It is a strong swimmer and is difficult to capture by hand. The life history of the Ozark crayfish is typical of stream crayfish in the Ozarks. I observed copulation in the fall, from mid-September through mid-November. In one instance a male Ozark crayfish was observed copulating with a female of the coldwater crayfish (*O. eupunctus*), and a hybrid between these species was collected from the Eleven Point River. Sperm plugs were not observed in the sperm receptacles of mated females, as was the case with the coldwater crayfish and the woodland crayfish (*O. hylas*). Three of five female Ozark crayfish I collected in late February 1988 produced eggs in the laboratory between March 1 and March 16. Females with eggs were collected in the field on six dates between March 4 and

April 16. Females with young were not observed. In the Current River the Ozark crayfish begins egg laying in late February and its young are free-swimming about two weeks ahead of the golden crayfish.⁶¹ In my collections, females were much less common than males between mid-March and mid-May, suggesting that most retire to deep cavities or other inaccessible places when bearing eggs or young.

Twenty-three females from 1.4 to 3.1 inches long were carrying 30 to 287 eggs, averaging 103. These eggs were about 1.8 mm in diameter and ranged in color from light olive-green through brown to nearly black.

Males undergo a general molt from Form I to Form II in late April or early May, but the spring molt in females is delayed until reproduction is completed. Males remain in Form II until mid-September, molting back into Form I just prior to the fall breeding season.

This species reaches a length of 0.7 to 1.6 inches during its first growing season. Males and females grow at similar rates and achieve a similar maximum size. Many males, and probably also females, do not achieve maturity during their first year of life. Most individuals probably live about 2.5 years, dying after their second reproductive season.



Ozark crayfish at burrow entrance; Bull Creek, Taney County

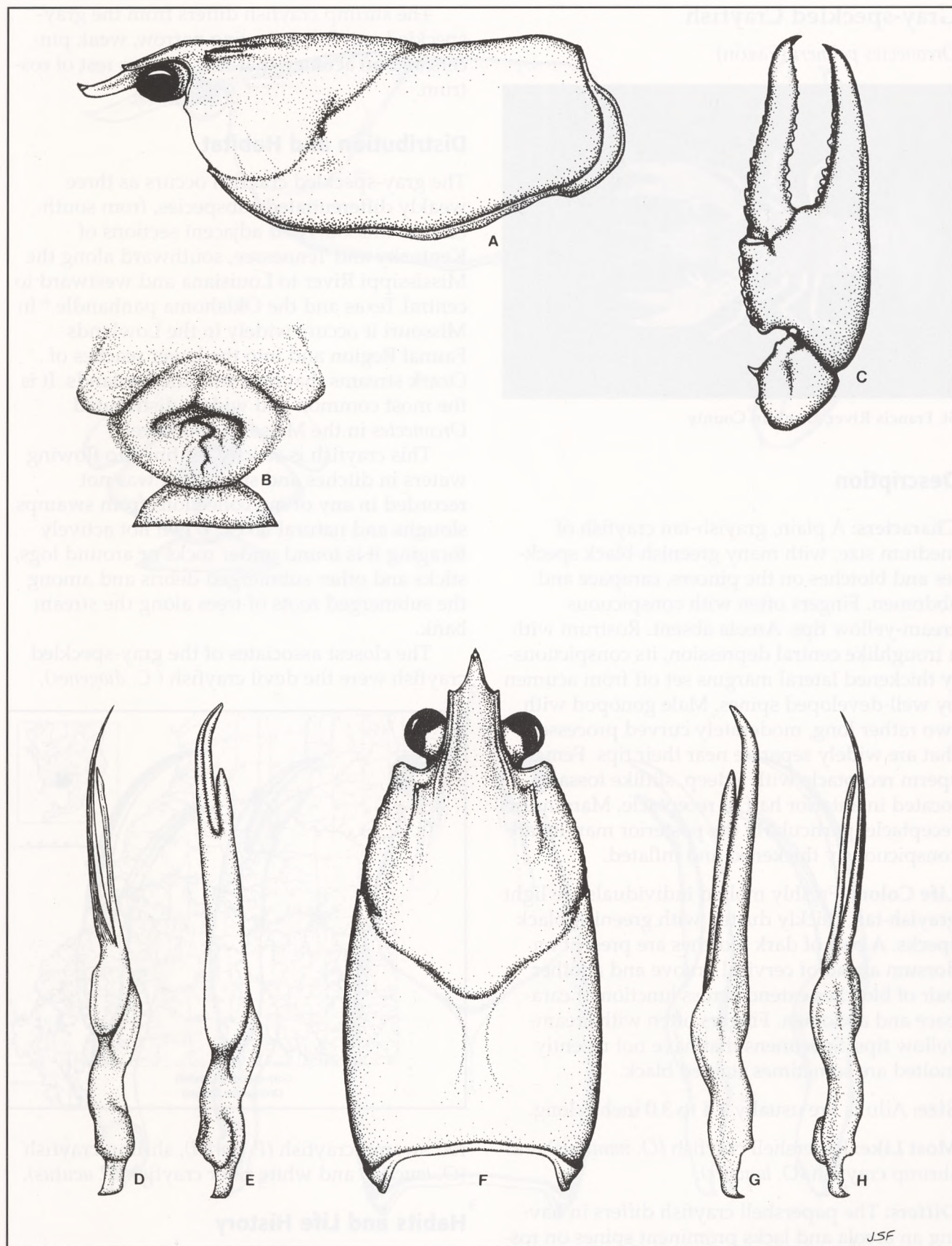
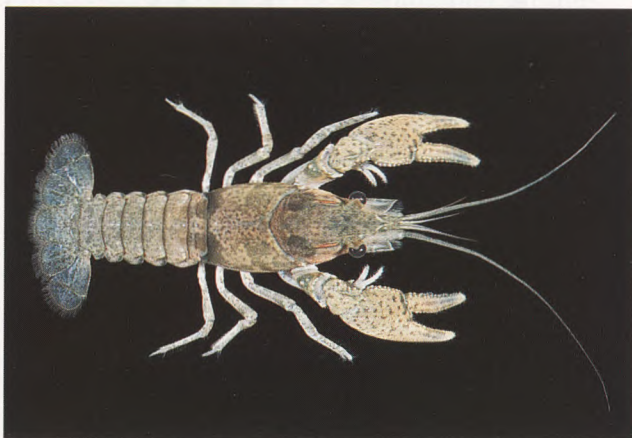


Plate 23. - *Orconectes ozarkae*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

Gray-speckled Crayfish

Orconectes palmeri (Faxon)



St. Francis River, Dunklin County

Description

Characters: A plain, grayish-tan crayfish of medium size, with many greenish-black speckles and blotches on the pincers, carapace and abdomen. Fingers often with conspicuous cream-yellow tips. Areola absent. Rostrum with a troughlike central depression, its conspicuously thickened lateral margins set off from acumen by well-developed spines. Male gonopod with two rather long, moderately curved processes that are widely separate near their tips. Female sperm receptacle with a deep, slitlike fossa located in anterior half of receptacle. Margins of receptacle, particularly the posterior margin, are conspicuously thickened and inflated.

Life Colors: Freshly molted individuals are light grayish-tan, thickly dusted with greenish-black specks. A pair of dark blotches are present on dorsum ahead of cervical groove and another pair of blotches extend across junction of carapace and abdomen. Fingers often with cream-yellow tips. Specimens that have not recently molted are sometimes stained black.

Size: Adults are usually 1.4 to 3.0 inches long.

Most Like: Papershell crayfish (*O. immunis*) and shrimp crayfish (*O. lancifer*).

Differs: The papershell crayfish differs in having an areola and lacks prominent spines on rostrum at base of acumen. This species has not occurred in the same collections with the gray-speckled crayfish in Missouri.

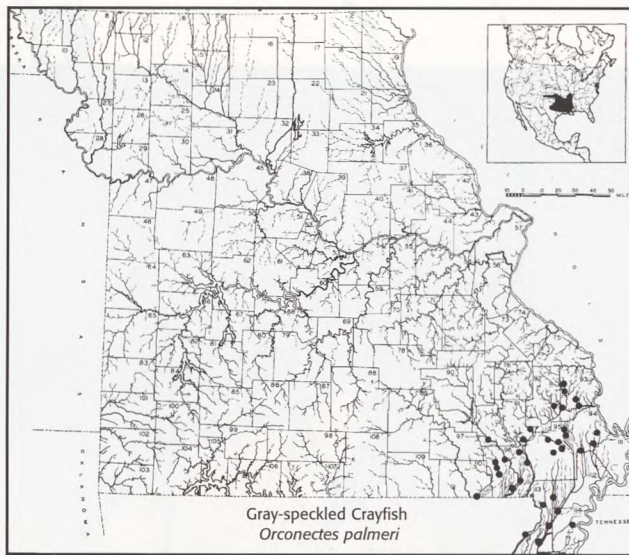
The shrimp crayfish differs from the gray-speckled crayfish in having narrow, weak pincers and an acumen that is as long as rest of rostrum.

Distribution and Habitat

The gray-speckled crayfish occurs as three weakly differentiated subspecies, from southeastern Missouri and adjacent sections of Kentucky and Tennessee, southward along the Mississippi River to Louisiana and westward to central Texas and the Oklahoma panhandle.⁴⁰ In Missouri it occurs widely in the Lowlands Faunal Region and into the lower reaches of Ozark streams that flow into the lowlands. It is the most common and widely distributed *Orconectes* in the Missouri "bootheel."

This crayfish is strictly confined to flowing waters in ditches and streams. It was not recorded in any of my collections from swamps, sloughs and natural lakes. When not actively foraging it is found under rocks or around logs, sticks and other submerged debris and among the submerged roots of trees along the stream bank.

The closest associates of the gray-speckled crayfish were the devil crayfish (*C. diogenes*),



red swamp crayfish (*P. clarkii*), shrimp crayfish (*O. lancifer*) and white river crayfish (*P. acutus*).

Habits and Life History

At night this species is seen in the open, but in the daytime it retreats to the protection of cover. It is not classified as a burrower, but occasional-

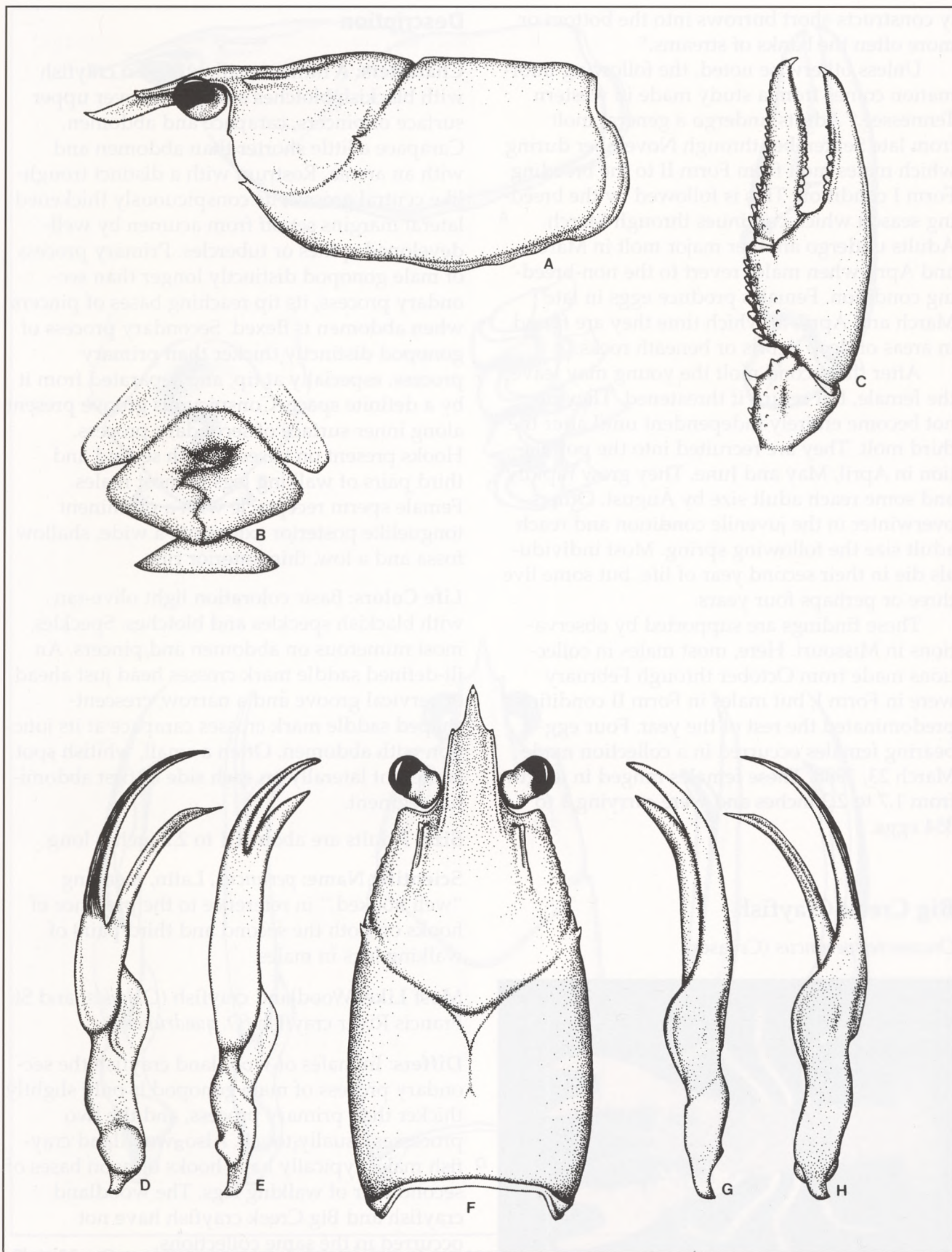


Plate 24. - *Orconectes palmeri*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.

ly constructs short burrows into the bottom or more often the banks of streams.⁴³

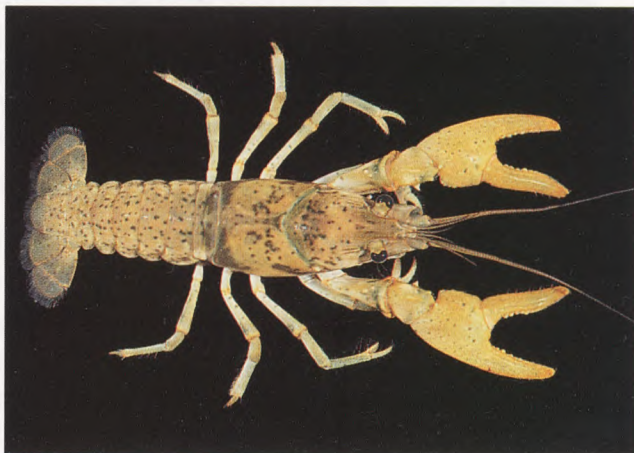
Unless otherwise noted, the following information comes from a study made in western Tennessee.⁶⁷ Adults undergo a general molt from late September through November during which males molt from Form II to the breeding Form I condition. This is followed by the breeding season which continues through March. Adults undergo another major molt in March and April when males revert to the non-breeding condition. Females produce eggs in late March and April, at which time they are found in areas of deep debris or beneath rocks.

After the second molt the young may leave the female, but return if threatened. They do not become entirely independent until after the third molt. They are recruited into the population in April, May and June. They grow rapidly and some reach adult size by August. Others overwinter in the juvenile condition and reach adult size the following spring. Most individuals die in their second year of life, but some live three or perhaps four years.

These findings are supported by observations in Missouri. Here, most males in collections made from October through February were in Form I, but males in Form II condition predominated the rest of the year. Four egg-bearing females occurred in a collection made March 23, 1988. These females ranged in length from 1.7 to 2.3 inches and were carrying 1 to 354 eggs.

Big Creek Crayfish

Orconectes peruncus (Creaser)



Little Creek, Iron County

Description

Characters: A rather small, olive-tan crayfish with blackish blotches and specks over upper surface of pincers, carapace and abdomen. Carapace a little shorter than abdomen and with an areola. Rostrum with a distinct trough-like central groove, its conspicuously thickened lateral margins set off from acumen by well-developed spines or tubercles. Primary process of male gonopod distinctly longer than secondary process, its tip reaching bases of pincers when abdomen is flexed. Secondary process of gonopod distinctly thicker than primary process, especially at tip, and separated from it by a definite space. Conspicuous groove present along inner surface of secondary process. Hooks present on bases of both second and third pairs of walking legs in most males. Female sperm receptacle with a prominent tonguelike posterior extension, a wide, shallow fossa and a low, thin anterior rim.

Life Colors: Basic coloration light olive-tan with blackish speckles and blotches. Speckles most numerous on abdomen and pincers. An ill-defined saddle mark crosses head just ahead of cervical groove and a narrow, crescent-shaped saddle mark crosses carapace at its junction with abdomen. Often a small, whitish spot is present laterally on each side of first abdominal segment.

Size: Adults are about 1.1 to 2.2 inches long.

Scientific Name: *peruncus*, Latin, meaning "well hooked," in reference to the presence of hooks on both the second and third pairs of walking legs in males.

Most Like: Woodland crayfish (*O. hylas*) and St. Francis River crayfish (*O. quadruncus*).

Differs: In males of woodland crayfish the secondary process of male gonopod is only slightly thicker than primary process, and the two processes usually touch. Also, woodland crayfish males typically have hooks only on bases of second pair of walking legs. The woodland crayfish and Big Creek crayfish have not occurred in the same collections.

In the St. Francis River crayfish, the two processes of the Form I male gonopod are nearly equal in length and are not separated by a

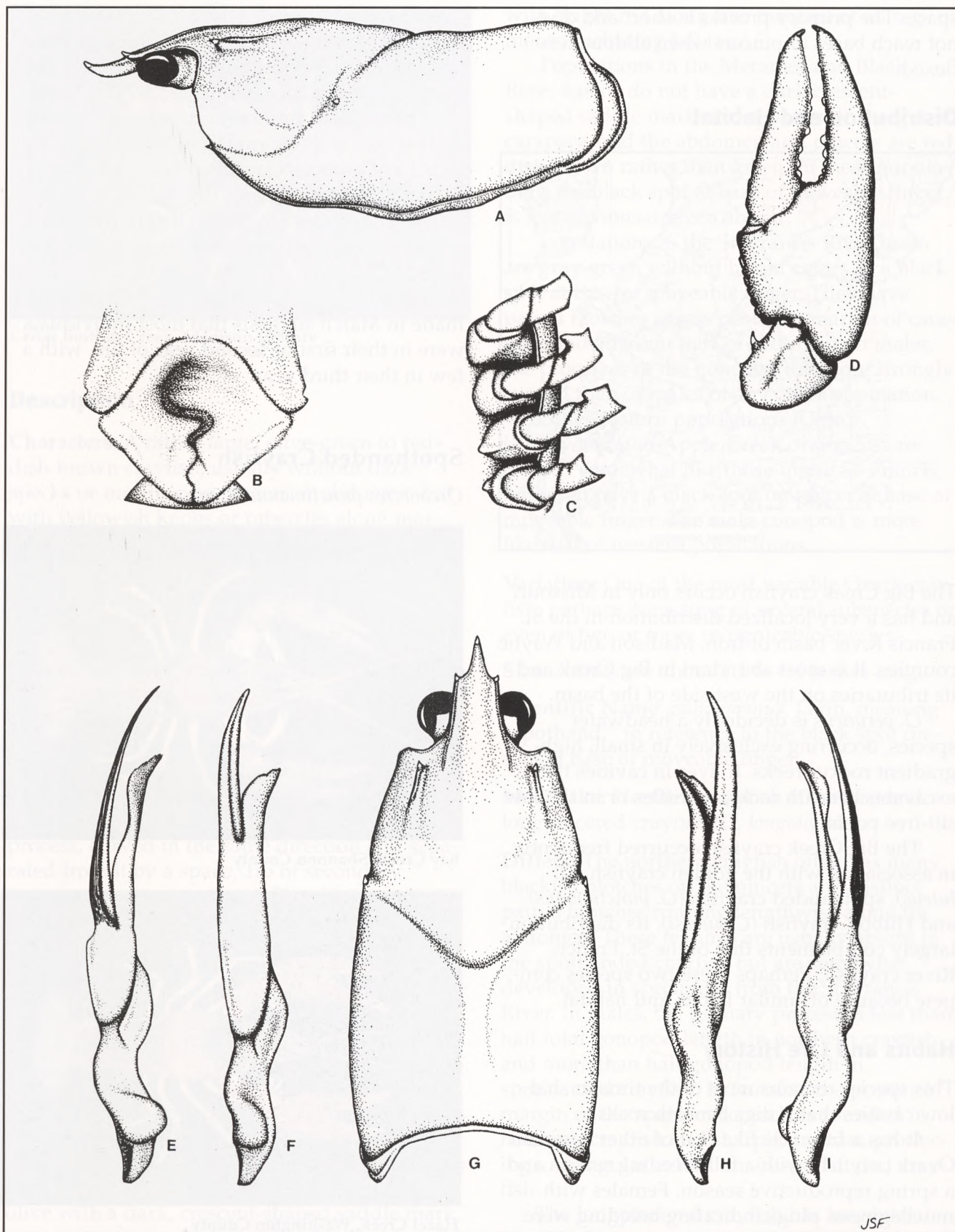
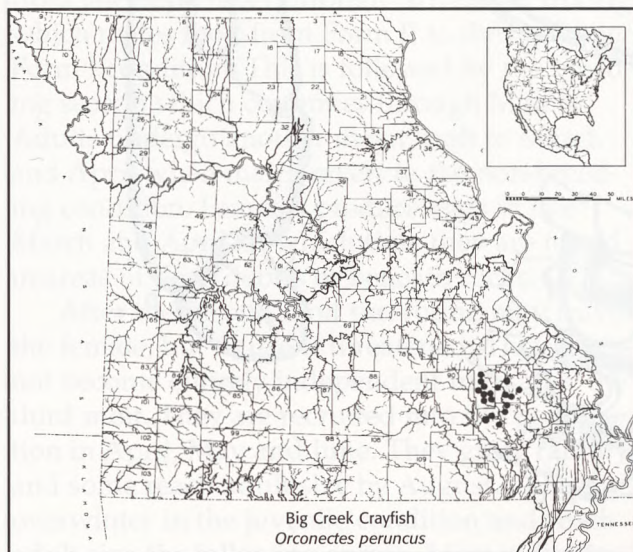


Plate 25. - *Orconectes peruncus*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

space. The primary process is short and does not reach bases of pincers when abdomen is flexed.

Distribution and Habitat



The Big Creek crayfish occurs only in Missouri and has a very localized distribution in the St. Francis River basin of Iron, Madison and Wayne counties. It is most abundant in Big Creek and its tributaries on the west side of the basin.

O. peruncus is decidedly a headwater species, occurring exclusively in small, high-gradient rocky creeks. It lives in cavities that it excavates beneath rocks, on riffles or in shallow silt-free pools.

The Big Creek crayfish occurred frequently in association with the golden crayfish (*O. luteus*), spothanded crayfish (*O. punctimanus*) and Hubbs' crayfish (*C. hubbsi*). Its distribution largely complements that of the St. Francis River crayfish. Perhaps these two species compete because of similar habits and habitat.

Habits and Life History

This species remains most of the time in shallow cavities that it digs beneath rocks.

It has a life cycle like that of other common Ozark crayfish, with a fall breeding season and a spring reproductive season. Females with mucilaginous plugs indicating breeding were found in October, November, March and May. A female collected March 24, 1988 produced eggs in the laboratory four days later. Other females carrying eggs were collected in Clark

Creek, Wayne County, March 29, 1984. The presence of females with sperm plugs in collections made May 20, 1987 suggests that egg production had not been completed by that date.

The males in these collections were recently molted and in the Form II condition. Males collected in October, November, February and March were mostly Form I.

Seven females ranging in length from 1.4 to 5.5 inches were carrying 15 to 123 eggs, averaging 61.

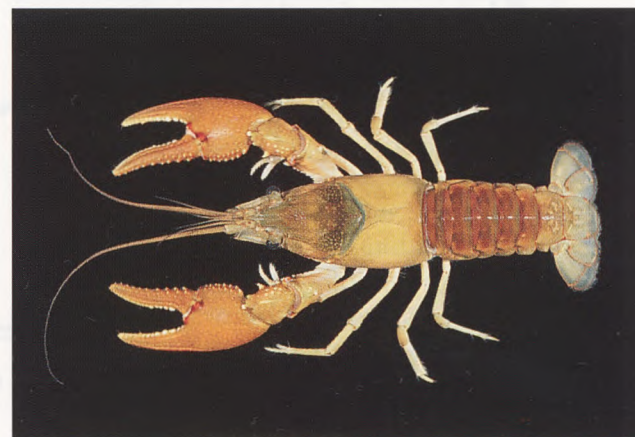
Length-frequency analysis of collections made in March suggests that most individuals were in their first or second year of life, with a few in their third year.

Spothanded Crayfish

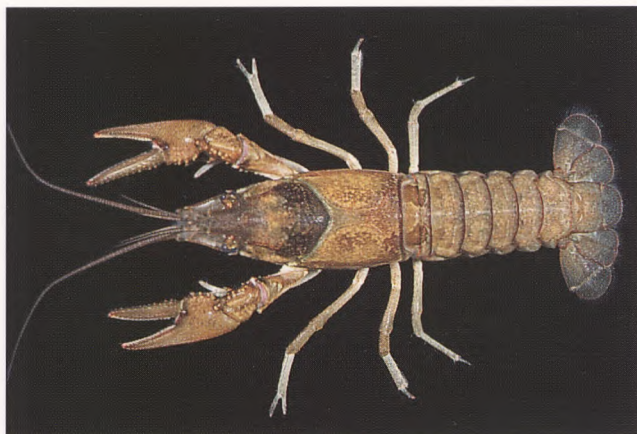
Orconectes punctimanus (Creaser)



Bay Creek, Shannon County



Hazel Creek, Washington County



Cedar Bottom Creek, Madison County

Description

Characters: A rather large, olive-green to reddish-brown crayfish, usually without dark specks or mottling on pincers or abdomen, but with yellowish knobs or tubercles along margins of pincers. In some populations there is a conspicuous and characteristic black spot on each pincer near base of moveable finger. Areola present. Rostrum with a distinct trough-like central depression, its thickened lateral margins set off by prominent tubercles or spines from acumen.

Male gonopod with two long, slender processes; primary process slightly to rather strongly curved, its tip reaching base of pincers when abdomen is flexed. Secondary process of gonopod somewhat shorter than primary process, curved in the same direction and separated from it by a space. Tip of secondary process tapering to a point. Shoulder usually present on inner surface of gonopod near base of primary process.

Female sperm receptacle with a triangular posterior extension and a deep fossa in its anterior half; fossa overhung by inflated anterior rim of annulus. Often, there is a distinct notch in anterior rim.

Life Colors: The spothanded crayfish varies widely in color between populations. In western populations (Current, Gasconade and White River basins) the carapace is reddish-brown to olive with a dark, crescent-shaped saddle mark across carapace at its junction with the abdomen. The pincers are green with a characteristic black spot on each pincer near base of moveable finger. The abdomen is light green

with bright red along free margins of all segments, including tail fan.

Populations in the Meramec and Black River basins do not have a dark crescent-shaped saddle mark across posterior margin of carapace, and the abdomen and pincers are reddish-brown rather than green. In these populations the black spot at base of moveable finger is less obvious or even absent.

Populations in the St. Francis River basin are gray-green without bright colors or a black spot at base of moveable finger. They have paired blotches across posterior margin of carapace and adjacent part of abdomen. In males, the processes of the gonopod are more strongly curved than in males of any other population.

Other eastern populations (Castor, Whitewater and Apple Creek drainages) are colored somewhat like those in the St. Francis, but often have a black spot on pincer at base of moveable finger. The male gonopod is more like that of western populations.

Variation: One of the most variable Ozark crayfish, perhaps consisting of several subspecies or even of two or more recognizable species.

Size: Adults are about 1.3 to 4.4 inches long.

Scientific Name: *punctimanus*, Latin, meaning "spothanded," in reference to the black spot present at base of moveable finger.

Most Like: Northern crayfish (*O. virilis*) and longpincered crayfish (*O. longidigitus*).

Differs: The northern crayfish often has many blackish blotches on the pincers and distinct paired blotches running lengthwise along the abdomen. These features are usually absent in the spothanded crayfish but are somewhat developed in specimens from the St. Francis River. In males, the primary process is less than half total gonopod length in northern crayfish and more than half gonopod length in spothanded crayfish. In females, the posterior margin of the sperm receptacle is rounded in northern crayfish and sharply angular, producing a triangular extension, in spothanded crayfish.

The longpincered crayfish has long, slender, blue-black pincers, compared to proportionately shorter, broader and light green or reddish-brown pincers of the spothanded crayfish; the acumen is more than half the length of rest of

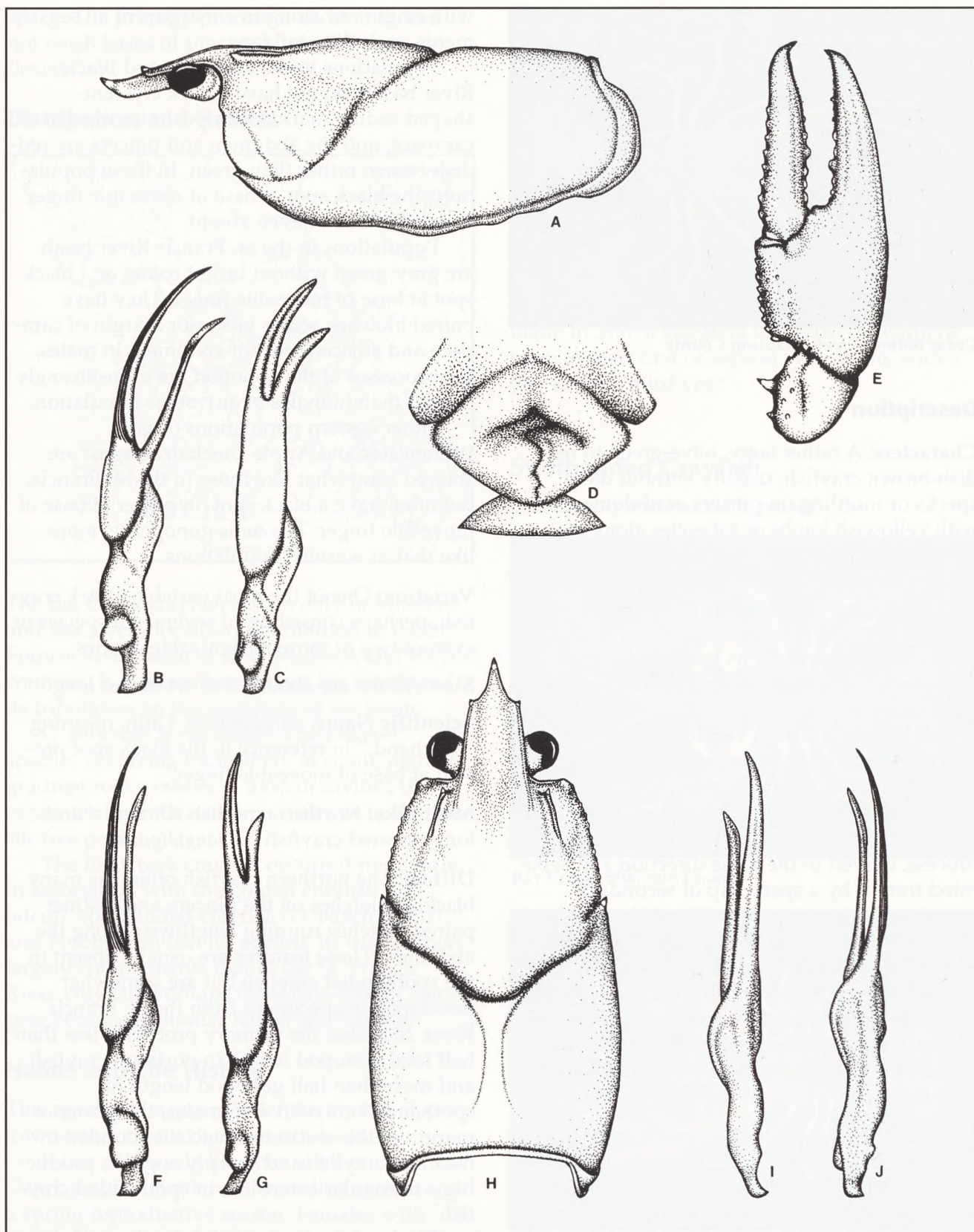
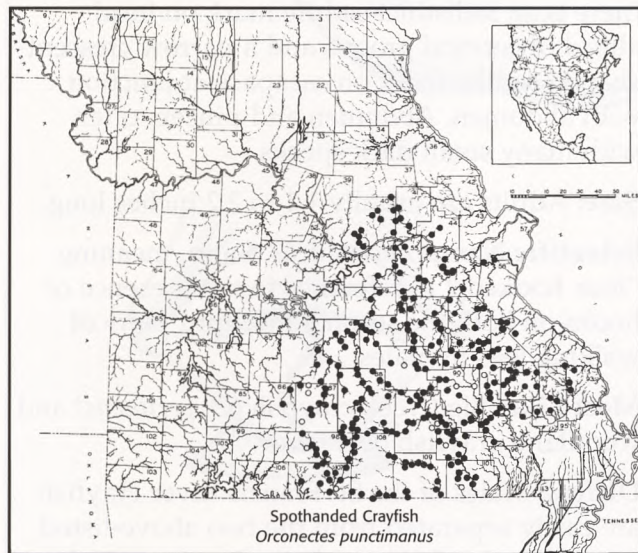


Plate 26. - *Orconectes punctimanus*. A, lateral view of carapace; B, mesial view of form I male gonopod (St. Francis River); C, mesial view of Form II male gonopod (St. Francis River); D, female sperm receptacle; E, dorsal view of right pincer; F, mesial view of Form I male gonopod (Eleven Point River); G, mesial view of Form II male gonopod (Eleven Point River); H, dorsal view of carapace; I, lateral view of Form II male gonopod; J, lateral view of Form I male gonopod.

rostrum compared to less than half in spothanded crayfish. The longpincer crayfish never has a saddle mark across carapace at junction with abdomen or a black spot at base of moveable finger.



Distribution and Habitat

The range of the spothanded crayfish includes most of the eastern one-half of the Ozark Region in Missouri and extends southward into adjacent counties of northern Arkansas. The Missouri range includes parts of Callaway, Montgomery and Warren counties north of the Missouri River. This species does not occur west of the Gasconade drainage in the northern Ozarks or west of the North Fork drainage in the White River Basin. It occurs in Apple Creek, Cape Girardeau County, but has not been otherwise recorded in direct tributaries of the Mississippi River south of the Meramec.

Over most of its Missouri range the spothanded crayfish is second or third in abundance to the golden crayfish (*O. luteus*), the Ozark crayfish (*O. ozarkae*) or the ringed crayfish (*O. neglectus*). However, it is often the most abundant crayfish in protected areas along the shore, particularly where there is abundant cover in the form of vegetation, detritus or large rocks. It was common in streams of all sizes, from small headwater creeks to large Ozark rivers, and also in spring branches. This species was the most frequently encountered eyed and pigmented crayfish in cave streams within its range.

Eighteen other species of crayfish occurred

in the same collections as the spothanded crayfish. Its most frequent associate, by far, was the golden crayfish, which occurred in 52 percent of spothanded crayfish collections. Other common associates, in decreasing order of frequency, were the Ozark crayfish, saddlebacked crayfish (*O. medius*), Hubbs' crayfish (*C. hubbsi*) and the ringed crayfish.

Habits and Life History

This is an alert, active crayfish and a strong swimmer. It is nocturnal and was observed at night grazing on algae growing on rocks. On one occasion several large adults were observed feeding on a dead sucker lying on the bottom of a pool. This species excludes the golden crayfish from its preferred habitat, vegetative cover, because of its larger size in all life history stages.⁷⁷

The spothanded crayfish has a life cycle similar to that of other stream crayfish in the Ozark Region. Breeding was observed during September and October, and females with eggs or young were observed in March and May. Nine of 10 females with eggs were collected in March. The one egg-bearing female collected in May came from a spring branch where ovulation might have been delayed by cool temperatures. The single female with young was observed in May. In Missouri's Current and Jacks Fork rivers eggs of the spothanded crayfish reportedly hatched about three weeks before those of the golden crayfish (*O. luteus*).⁷⁷

In most Ozark crayfish there is a definite alternation between the Form I and the Form II condition, with Form I males predominating from September or October until March, and Form II males predominating the rest of the year. This alternation seems less clear in the spothanded crayfish. In my collections, Form II males predominated over Form I males or were nearly as frequent during all months of the year. However, Form I males were most numerous during September and October, which corresponds to the fall breeding season. Form I males were present in small numbers throughout the year, but were quite scarce during the April - August period.

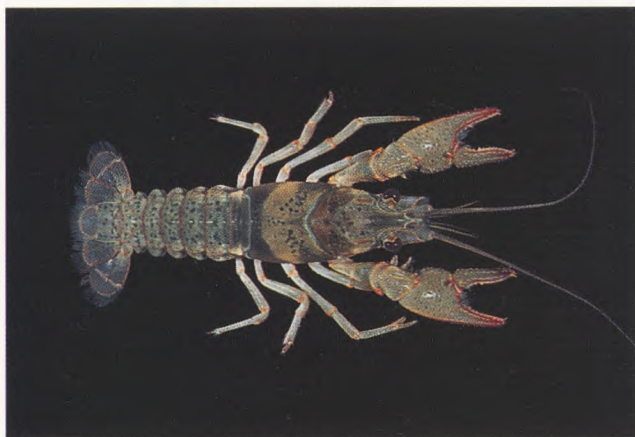
In collections made March 22, 1988, most males and females had recently molted and the males were Form II. The only adults that had not molted recently were a few Form I males

and females with eggs or a sperm plug. Apparently adults undergo a general molt as water temperatures rise in early spring and the molt is delayed in females that produce young. Most males remain in the Form II condition through the summer, with many molting back into the Form I condition in the fall.

Length-frequency analysis indicates that young of the spothanded crayfish reach lengths of about 1.1 to 2.1 inches by late October, and some of these mature during their first year of life. The normal life span is about two years, but some individuals probably live three years or more.

St. Francis River Crayfish

Orconectes quadruncus (Creaser)



Logan Creek, Wayne County

Description

Characters: A rather small, dark brown crayfish with blackish blotches or specks over upper surfaces of pincers, carapace and abdomen. Carapace a little shorter than abdomen; areola present. Rostrum with a distinct troughlike central groove, its conspicuously thickened lateral margins set off from acumen by well-developed spines or tubercles.

Primary process of male gonopod short, its tip not reaching bases of pincers when abdomen is flexed. Secondary process thicker than primary process, especially near tip, not separated from it by a space, with a conspicuous groove on inner surface. Usually, hooks are present on bases of both second and third pair of walking legs, often small on third pair.

Female sperm receptacle with a prominent tonguelike posterior extension, a wide, shallow fossa and a low, crescent-shaped anterior rim.

Life Colors: Basic coloration dark reddish-brown with dark speckles and blotches. Usually there is an indistinct saddle mark on head ahead of cervical groove and a narrow crescent-shaped saddle mark on carapace at junction with abdomen. Abdomen and pincers often with many small dark specks.

Size: Adults are usually 1.1 to 2.2 inches long.

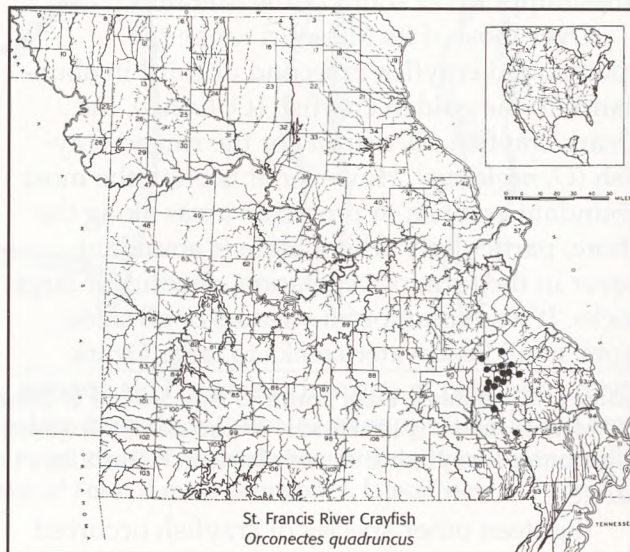
Scientific Name: *quadruncus*, Latin, meaning "four hooked," in reference to the presence of hooks on both the second and third pairs of walking legs in males.

Most Like: Big Creek crayfish (*O. peruncus*) and woodland crayfish (*O. hylas*).

Differs: Males of the St. Francis River crayfish are easily separated from the two above-listed species by the shorter principal process of the gonopod, which is nearly equal in length to secondary process and not reaching the base of pincers when abdomen is flexed. Also, fossa of female sperm receptacle is somewhat deeper in the other two species, especially *O. hylas*.

Distribution and Habitat

This crayfish occurs only in Missouri, where it has a localized distribution in the St. Francis River drainage of St. Francis, Iron, Madison and Wayne counties. It is most abundant and widely distributed in the basin above the mouth of Twelve-mile Creek. The original description of



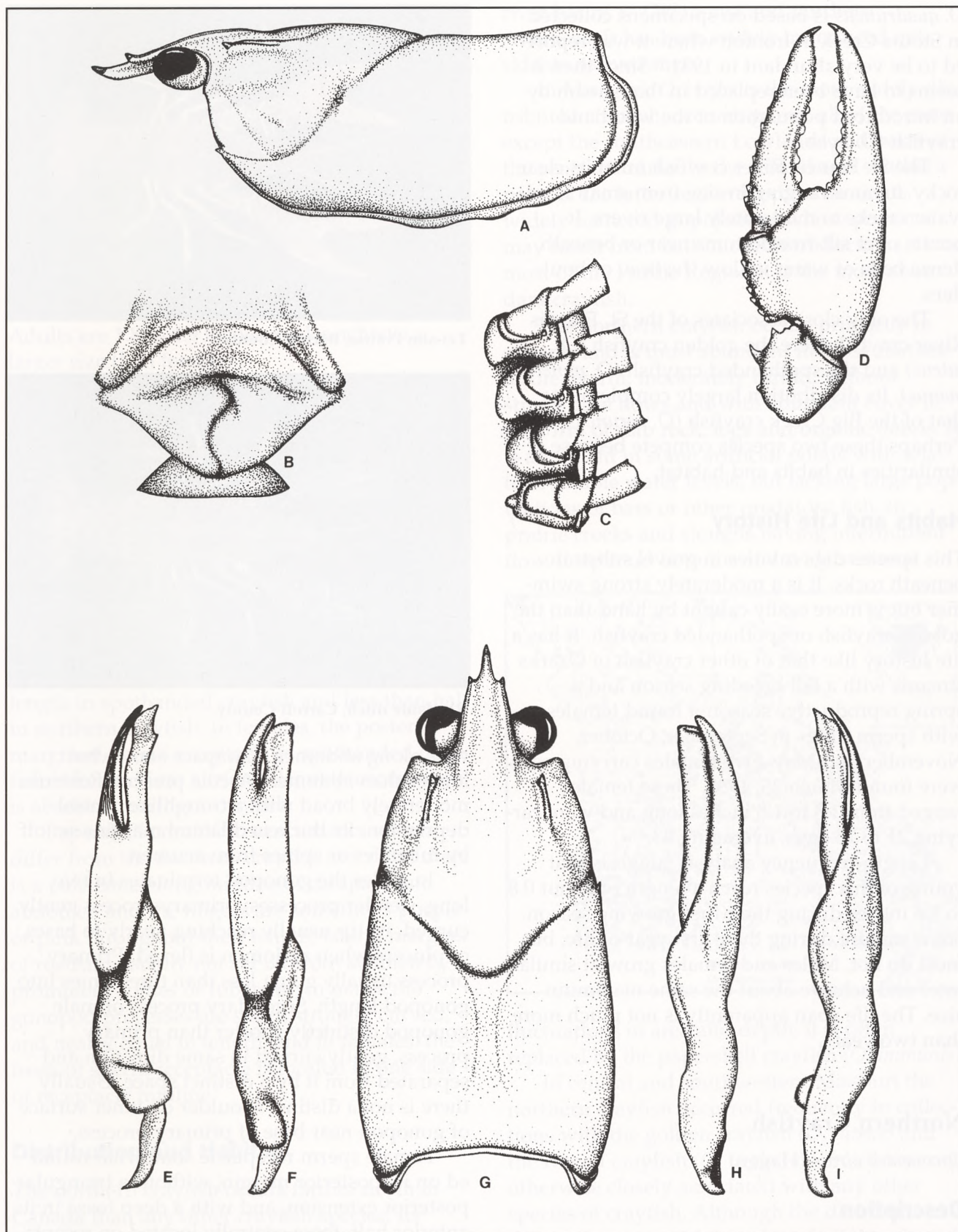


Plate 27. - *Orconectes quadruncus*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

O. quadruncus is based on specimens collected in Stouts Creek at Ironton where it was reported to be very abundant in 1931.¹⁶ Since then it seems to have been replaced in that stream by an introduced population of the woodland crayfish (*O. hylas*).

The St. Francis River crayfish inhabits clear, rocky streams ranging in size from small head-water creeks to moderately large rivers. It occurs over silt-free bottoms near or beneath dense beds of water willow (*Justicia*) or boulders.

The only close associates of the St. Francis River crayfish were the golden crayfish (*O. luteus*) and the spothanded crayfish (*O. punctimanus*). Its distribution largely complements that of the Big Creek crayfish (*O. peruncus*). Perhaps these two species compete because of similarities in habits and habitat.

Habits and Life History

This species digs cavities in gravel substrate beneath rocks. It is a moderately strong swimmer but is more easily caught by hand than the golden crayfish or spothanded crayfish. It has a life history like that of other crayfish of Ozarks streams with a fall breeding season and a spring reproductive season. I found females with sperm plugs in September, October, November and May. Five females carrying eggs were found March 25, 1985. These females ranged from 1.3 to 1.8 inches long and were carrying 21 to 78 eggs, averaging 43.

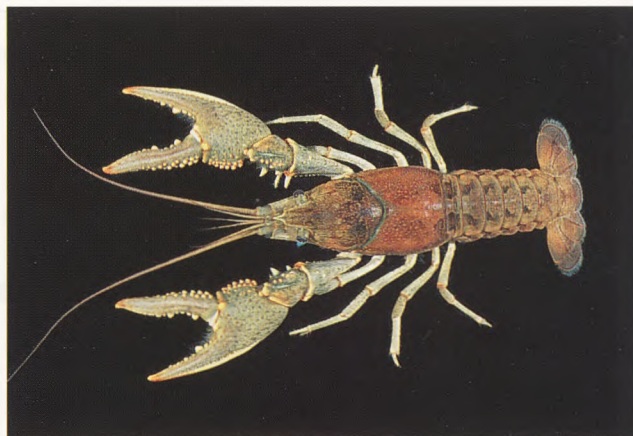
Length-frequency analysis suggests that young of this species reach a length of about 0.8 to 1.6 inches during their first growing season. Some mature during their first year of life, but most do not. Males and females grow at similar rates and achieve about the same maximum size. The life span apparently is not much more than two years.

Northern Crayfish

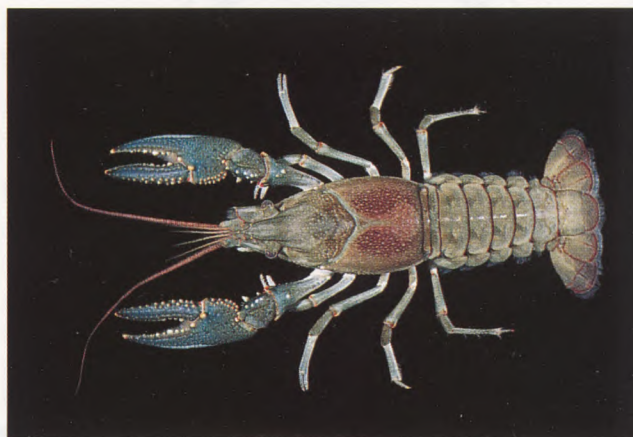
Orconectes virilis (Hagen)

Description

Characters: A large, reddish-brown or green crayfish with prominent yellowish knobs or tubercles along inner margins of pincers and with paired blackish blotches extending length-



Tzi-sho Prairie, Barton County



Roadside ditch, Carroll County

wise along abdomen. Carapace somewhat longer than abdomen. Areola present. Rostrum moderately broad with a troughlike central depression, its thickened lateral margins set off by tubercles or spines from acumen.

In males the gonopod terminates in two long, slender processes; primary process gently curved, its tip usually reaching nearly to bases of pincers when abdomen is flexed. Primary process usually going less than three times into gonopod length. Secondary process of male gonopod distinctly shorter than primary process, gently curved in same direction and separated from it by a distinct space. Usually there is not a distinct shoulder on inner surface of gonopod near base of primary process.

Female sperm receptacle somewhat rounded on its posterior margin, without a triangular posterior extension, and with a deep fossa in its anterior half; fossa centrally located on receptacle midline and slightly overhung by anterior rim of receptacle.

Life Colors: Carapace usually reddish-brown or

olive brown. Abdomen green with two lengthwise rows of blackish blotches. Blotches most evident in smaller individuals, particularly those that have recently molted. Pincers green or blue-green with yellowish bumps or tubercles along inner margin of palm and cutting edges of fingers. Often pincers have a conspicuously white outer margin and fingers have orange or orange-red tips. Typically, there are many blackish specks or blotches on pincers, but no black spot at base of moveable finger.

Size: One of the largest Missouri species. Adults are 1.8 to 4.9 inches; males achieve a larger size than females.

Most Like: Spothanded crayfish (*O. punctimanus*) and papershell crayfish (*O. immunis*).

Differs: The spothanded crayfish usually does not have dark blotches or specks on its pincers but may have a prominent black spot at base of moveable finger. This spot is absent in northern crayfish. In most populations of spothanded crayfish there is a narrow crescent-shaped saddle mark at posterior margin of carapace which is absent in northern crayfish. In males the primary process is more than half of total gonopod length in spothanded crayfish and less than half in northern crayfish. In females, the posterior margin of sperm receptacle of spothanded crayfish is formed into a triangular extension which is absent in northern crayfish.

Papershell crayfish characteristics which differ from the northern crayfish are: often there is a pale zone along midline of carapace and abdomen and the fingers are sometimes purple or pink throughout their length; lateral margins of rostrum usually not set off from acumen by prominent spines or tubercles; in males the gonopod processes are short, strongly curved, and nearly equal in length; and in females, the fossa of sperm receptacle is located to one side of receptacle midline.

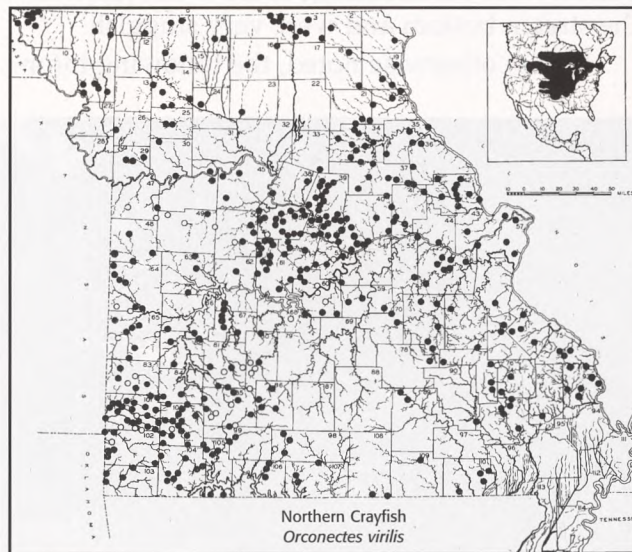
Distribution and Habitat

The northern crayfish occurs farther north in Canada than any other crayfish species. Its native range extends as far north as the southern tip of Hudson Bay. Southward, it occurs from New England to western Montana and through the Missouri, Mississippi and Ohio

river basins to Oklahoma and northern Arkansas. It has been widely introduced outside its native range.

In Missouri, *O. virilis* is the most widely distributed crayfish, occurring over all of the state except the southeastern Lowlands and parts of the central Ozarks. In the central and southern parts of the latter region it occurs as small, widely scattered populations whose presence may result from bait-bucket introductions. Over most of the Prairie Region it is the most abundant crayfish.

The northern crayfish occurs primarily in streams and is most abundant in those that are fertile, warm, moderately turbid, without strong base flows and with abundant cover in the form of slab rock, logs and organic debris. It is abundant in some artificial ponds with relatively stable water levels, but lacking large populations of bass or other predatory fish. In prairie creeks and sloughs having intermittent flow, deep mud bottoms and wide seasonal



fluctuations in area and depth, it is often replaced by the papershell crayfish (*O. immunis*).

In central and southwestern Missouri the northern crayfish occurred frequently in collections with the golden crayfish (*O. luteus*) and the ringed crayfish (*O. neglectus*), but it was not otherwise closely associated with any other species of crayfish. Although the distribution of the northern crayfish is rather similar to that of the papershell crayfish and the grassland crayfish (*P. gracilis*), these species generally occupy different habitats.

Habits and Life History

The northern crayfish is not a burrowing species but sometimes digs tunnels that extend horizontally into the bank and open underwater. More often, it is collected in the open or from around rocks, logs or deposits of organic debris. The adults are primarily nocturnal. This is an active, alert and agile crayfish. It exhibits marked seasonal variations in its activity patterns. Several workers in Michigan, Alberta and northwestern Iowa noted that the northern crayfish moves to deeper water in late summer or early fall to escape winter freezing.^{1,8,59}

When in deep water the crayfish are inactive and become covered with silt. They become active and return to shallow water as temperatures warm in the spring. In Missouri this species was scarce and difficult to capture from mid-November into March in habitats where it was abundant at other times of the year, suggesting that a similar period of inactivity occurs here. The few individuals I found during this period were beneath large rocks well seated in the stream bottom and were very sluggish.

Unless otherwise noted, the following infor-

mation is based on Iowa studies.^{10,73} This species feeds on a variety of plant and animal material, both living and dead. Breeding occurs over an extended period from early July until the adults retreat to deep water and become inactive with the onset of cold weather; it is resumed for a brief period in spring. The eggs are laid from mid-March to mid-April, and young are produced from mid-May to the third week of June. An interesting sidelight regarding parental care in this species was reported in Michigan.² Males constructed special tunnels in which mating and subsequent brooding of the eggs and young occurred. Usually only one male and one female occupied a tunnel but in one case a male and five females, each in a separate chamber, were present in the same tunnel.

Maturity was not reached in *O. virilis* until the second summer of life. In northwest Iowa, Form I males underwent a general molt into the Form II condition between mid-May and mid-June and molted back to Form I in July or August. In southwestern Iowa the spring molt occurred earlier, late April or early May, and males did not molt back to the Form I condition until late August. In Michigan, males grew at a



North Fork of Spring River, Jasper County; habitat of the northern crayfish, *O. virilis*. The ringed crayfish, *O. n. neglectus*, also occurs here.

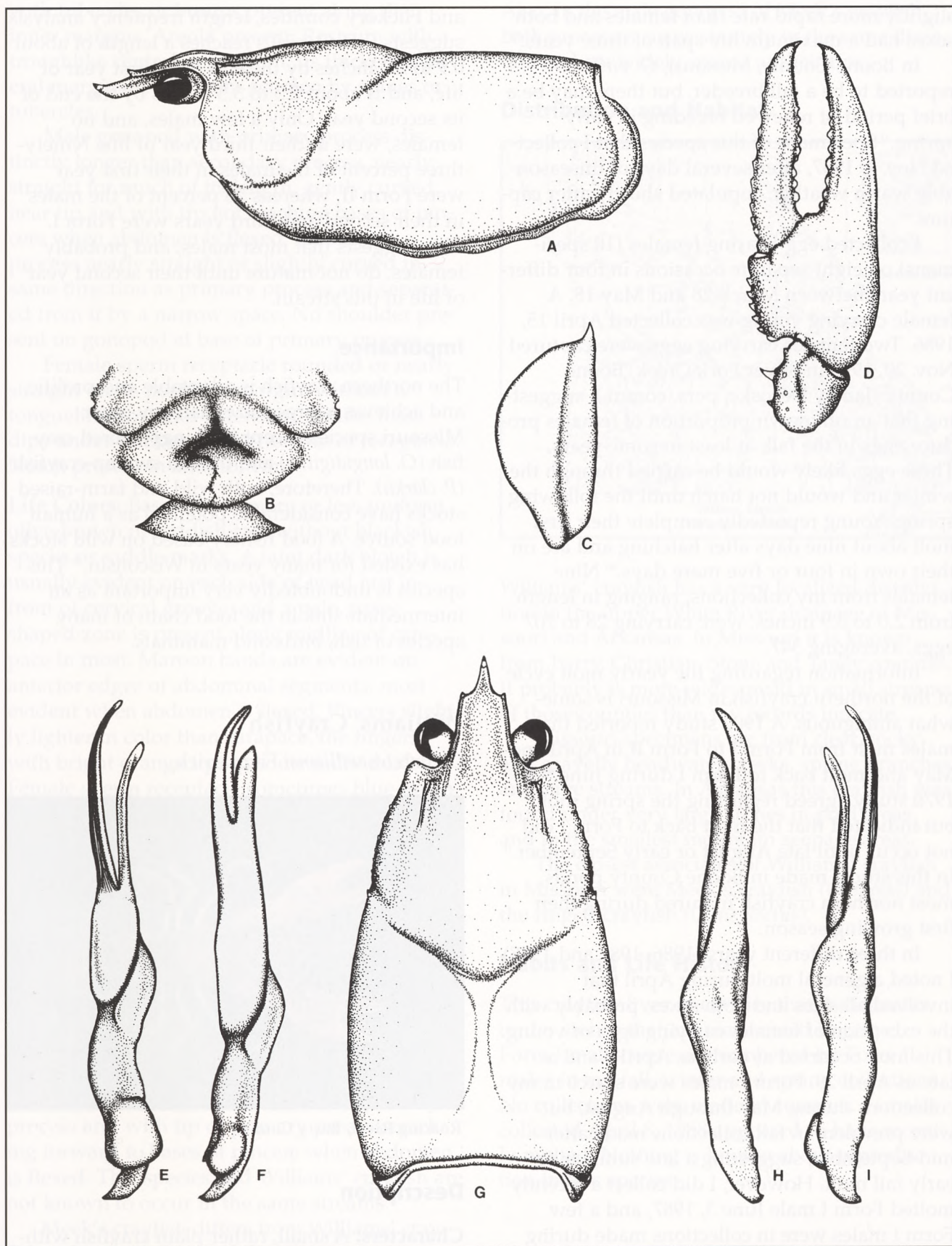


Plate 28. - *Orconectes virilis*. A, lateral view of carapace; B, female sperm receptacle; C, antennal scale; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

slightly more rapid rate than females and both sexes had a maximum life span of three years.⁵⁹

In Boone County, Missouri, *O. virilis* is reported to be a fall breeder, but there may be a brief period of renewed breeding in early spring.¹¹ Specimens of this species that I collected Nov. 4, 1987, after several days of unseasonably warm weather, copulated shortly after capture.

I collected egg-bearing females (10 specimens) on eight separate occasions in four different years between March 28 and May 18. A female carrying young was collected April 15, 1986. Two females carrying eggs were captured Nov. 20, 1990 in Silver Fork Creek, Boone County (Jamey Decoske, pers. comm.), suggesting that an unknown proportion of females produce eggs in the fall, at least in some years. These eggs likely would be carried through the winter and would not hatch until the following spring. Young reportedly complete their first molt about nine days after hatching and are on their own in four or five more days.⁸⁰ Nine females from my collections, ranging in length from 2.0 to 3.9 inches, were carrying 28 to 707 eggs, averaging 347.

Information regarding the yearly molt cycle of the northern crayfish in Missouri is somewhat ambiguous. A 1902 study reported that males molt from Form I to Form II in April and May and molt back to Form I during June.⁸⁰ A 1970 study agreed regarding the spring molt, but indicated that the molt back to Form I did not occur until late August or early September.¹¹ In this study, made in Boone County ponds, most northern crayfish matured during their first growing season.

In three different years (1986, 1987 and 1988) I noted a general molt during April that involved all sizes and both sexes, probably with the exception of females carrying eggs or young. This molt occurred as early as April 8 and as late as April 29. Form I males were scarce in my collections during May through August, but were prevalent in fall collections made after mid-September, suggesting a late summer or early fall molt. However, I did collect a recently molted Form I male June 3, 1987, and a few Form I males were in collections made during June, July and August, providing limited support for the conclusions of the 1902 study.

In the Little Pomme de Terre River, Benton

and Hickory counties, length frequency analysis suggests that *O. virilis* reaches a length of about 0.9 to 2.2 inches by the end of its first year of life, and is about 2.3 to 3.3 inches by the end of its second year. Only a few males, and no females, were in their third year of life. Ninety-three percent of the males in their first year were Form II, whereas 76 percent of the males in their second and third years were Form I. This suggests that most males, and probably females, do not mature until their second year of life in this stream.

Importance

The northern crayfish is adaptable and prolific, and achieves a larger size than any other Missouri species except the longpincered crayfish (*O. longidigitus*) and the red swamp crayfish (*P. clarkii*). Therefore, both wild and farm-raised stocks have considerable potential as a human food source. A food fishery based on wild stocks has existed for many years in Wisconsin.⁴⁹ This species is undoubtedly very important as an intermediate link in the food chain of many species of fish, birds and mammals.

Williams' Crayfish

Orconectes williamsi Fitzpatrick



Roaring River, Barry County

Description

Characters: A small, rather plain crayfish without bright colors or bold markings. Often a pale, vase-shaped zone is present along the carapace midline. Pincers broad and powerful,

with tubercles or bumps present along their inner margins. Areola present. Rostrum with a troughlike central depression, its thickened lateral margins set off from acumen by spines or tubercles.

Male gonopod with primary process distinctly longer than secondary process, nearly straight for much of its length, gently curved near tip and with tip not reaching bases of pincers when abdomen is flexed. Secondary process nearly straight or slightly curved in same direction as primary process and separated from it by a narrow space. No shoulder present on gonopod at base of primary process.

Female sperm receptacle rounded or nearly straight on its posterior margin, without a tongue-like posterior extension. Slitlike fossa dips under thickened anterior rim of receptacle. Notch present in anterior rim.

Life Colors: Base color a more or less uniform olive-brown or reddish-tan, without blackish specks or saddle marks. A faint dark blotch is usually evident on each side of head just in front of cervical groove, and a pale, vase-shaped zone is present along midline of carapace in most. Maroon bands are evident on anterior edges of abdominal segments, most evident when abdomen is flexed. Pincers slightly lighter in color than carapace, the fingers with bright orange tips in some individuals. Female sperm receptacle sometimes blue-green.

Size: Adults are about 1.2 to 2.0 inches long.

Scientific Name: Named in honor of Austin B. Williams, for his studies of Ozark crayfish.

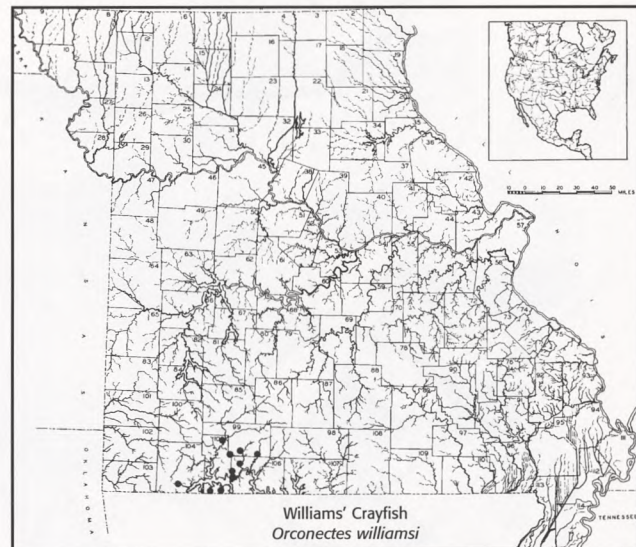
Most Like: Neosho midget crayfish (*O. macrus*), and Meek's crayfish (*O. meeki*).

Differs: The Neosho midget crayfish differs from Williams' crayfish as follows: prominent blackish saddle mark present at junction of carapace and abdomen; Form I male gonopod with a prominent shoulder at base of primary process and with tip of primary process reaching forward to bases of pincers when abdomen is flexed. This species and Williams' crayfish are not known to occur in the same streams.

Meek's crayfish differs from Williams' crayfish in having a dark saddle mark on carapace at its junction with abdomen and in having a definite spot on pincer near base of moveable finger.

Also, in the male gonopod of Meek's crayfish both processes curve strongly in the same direction and are widely spaced at their tips.

Distribution and Habitat



Williams' crayfish has a very localized distribution in the upper White River drainage of Missouri and Arkansas. In Missouri it is known from Barry, Christian, Stone and Taney counties. It probably is more widespread in small streams of those counties than my records indicate.

Missouri specimens are from clear, rocky and gravelly headwater creeks, spring branches and cave streams. In Arkansas this crayfish was found under very large stones in pool areas²⁵ and in the smallest mountain seepage areas.⁶

The closest associates of Williams' crayfish in Missouri were Meek's crayfish (*O. meeki*) and the ringed crayfish (*O. neglectus*).

Habits and Life History

This crayfish lives in cavities that it excavates under stones that are well-seated in gravel. Form I males were outnumbered by Form II males in my fall, winter and spring collections. No collections were made in summer. Females collected April 8, 1988 appeared to have recently molted. Nothing is known about reproduction in this species.

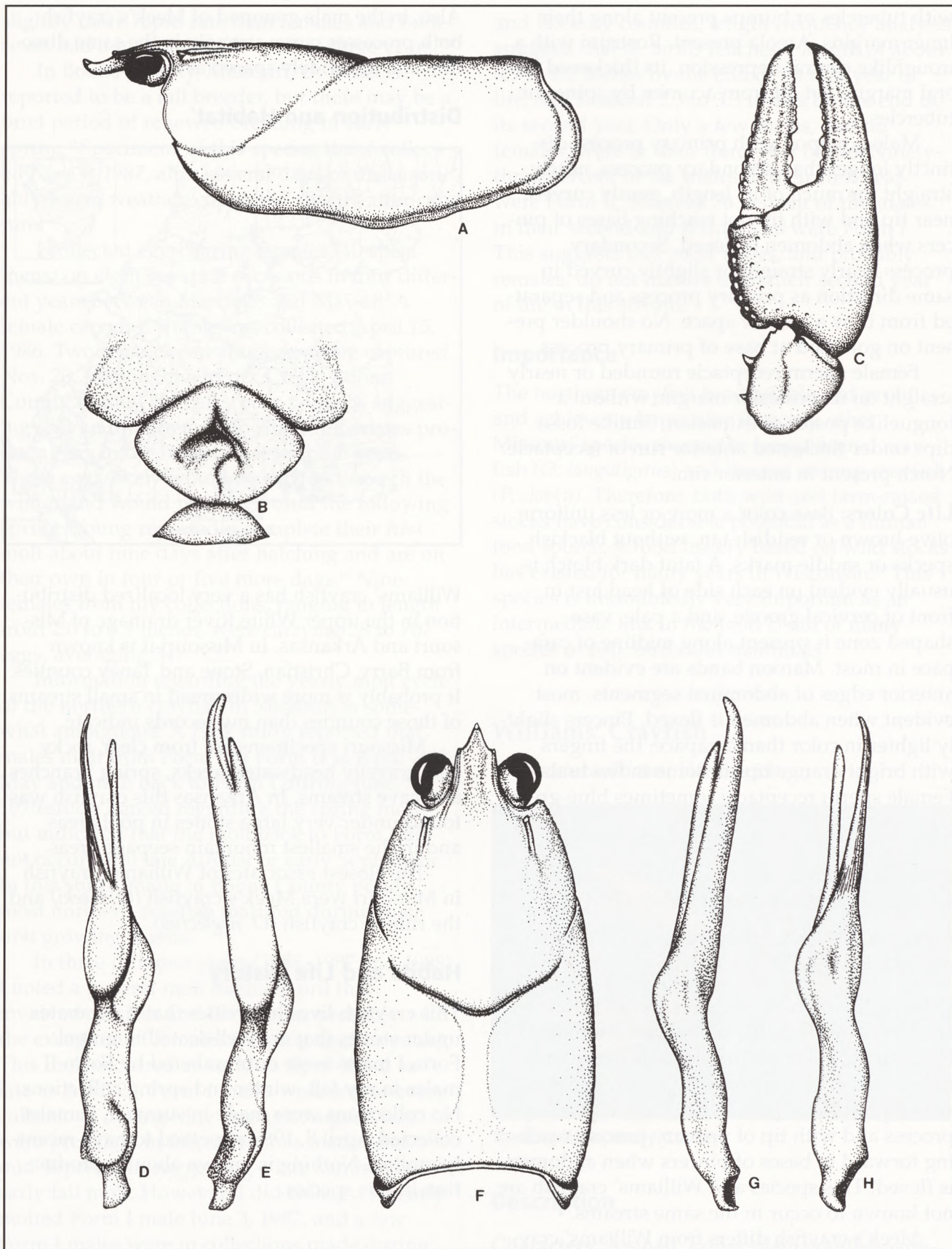


Plate 29. - *Orconectes williamsi*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, lateral view of Form I male gonopod.



Procambarus Ortmann

This genus includes more than 150 named species and subspecies. As a group, they are primarily southern in distribution, occurring as far south as Honduras and Cuba. In the United States most species are found along the Atlantic and Gulf Coastal plains, but a few occur northward in the Mississippi Valley to Wisconsin.

The Form I male gonopod terminates in two to four short processes, partially obscured in some species by thickly set setae. In males, hooks are present on the bases of the second, and in some species also the third, pair of walking legs.

Four species of *Procambarus* occur in Missouri. Two of these, *P. clarkii* and *P. viaeveridus*, are restricted to the Lowland Faunal Region, and another, *P. acutus*, has only a limited distribution elsewhere in the state. The fourth species, *P. gracilis*, occurs almost exclusively in the Prairie Region. All Missouri *Procambarus* exhibit a strong tendency to burrow.

White River Crayfish

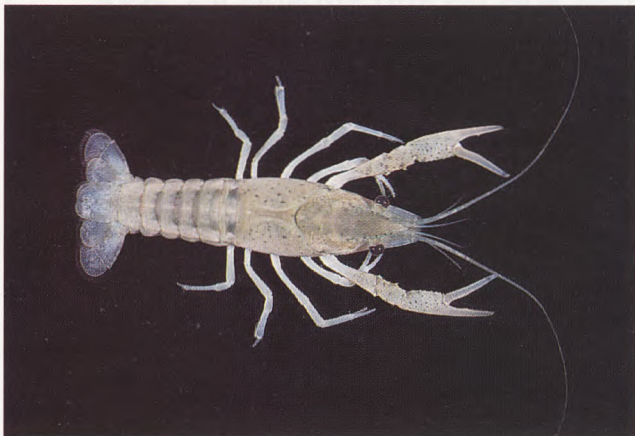
Procambarus acutus (Girard)



Sand Pond, Ripley County



(Above) Poplar Bluff Conservation Area, Butler County
(Below) Subadult; unnamed ditch, Dunklin County



Description

Characters: A large dark red or brown crayfish with a blackish, wedge-shaped pattern on the abdomen and long, slender pincers. Carapace laterally compressed, its sides with a granular texture resulting from many small bumps or

tubercles. Areola present, grooves separated at midpoint by a narrow space. Rostrum with a troughlike central depression, its margins strongly converging anteriorly. Acumen short, the spines or tubercles separating it from remainder of rostrum small or absent.

Male gonopod with four short processes, three of which are strongly curved laterally from midline. Processes partly obscured by hairlike structures. Gonopod tip without a prominent shoulder. Hooks present on bases of second and third pairs of walking legs. Female sperm receptacle with fossa located to right of body midline and overhung by the largest of three tubercles present on surface of receptacle.

Life Colors: Adults are typically burgundy red with a black wedge-shaped pattern on the abdomen. Tubercles on sides of body and pincers cream-colored. Occasional adults are brown instead of red. Juveniles are pale gray with blackish spots laterally on carapace and do not have a blackish wedge on abdomen. Subadults are intermediate in color between juveniles and adults.

Size: Adults are about 2.6 to 4.9 inches long.

Scientific Name: *acutus*, Latin, meaning sharp or pointed.

Most Like: Red swamp crayfish (*P. clarkii*).

Differs: The red swamp crayfish lacks an areola and the acumen is set off from the remainder of the rostrum by well-developed spines. Also, the processes of the Form I male gonopod are more bladelike, not strongly curved laterally from the midline as in the white river crayfish.

Distribution and Habitat

The white river crayfish occurs along the Atlantic Coast from Maine to Georgia, along the Gulf Coast from the Florida Panhandle to Mexico, northward in the central Mississippi Valley, and in the southern Great Lakes from Minnesota to Ohio. In Missouri this species occurs throughout the Lowland Faunal Region, penetrating a short distance into the adjacent Ozarks, and northward along the Mississippi River flood plain to Clark County. Isolated populations were found along the Chariton River in Schuyler County and the Grand River in Livingston County. Perhaps it occurs at other

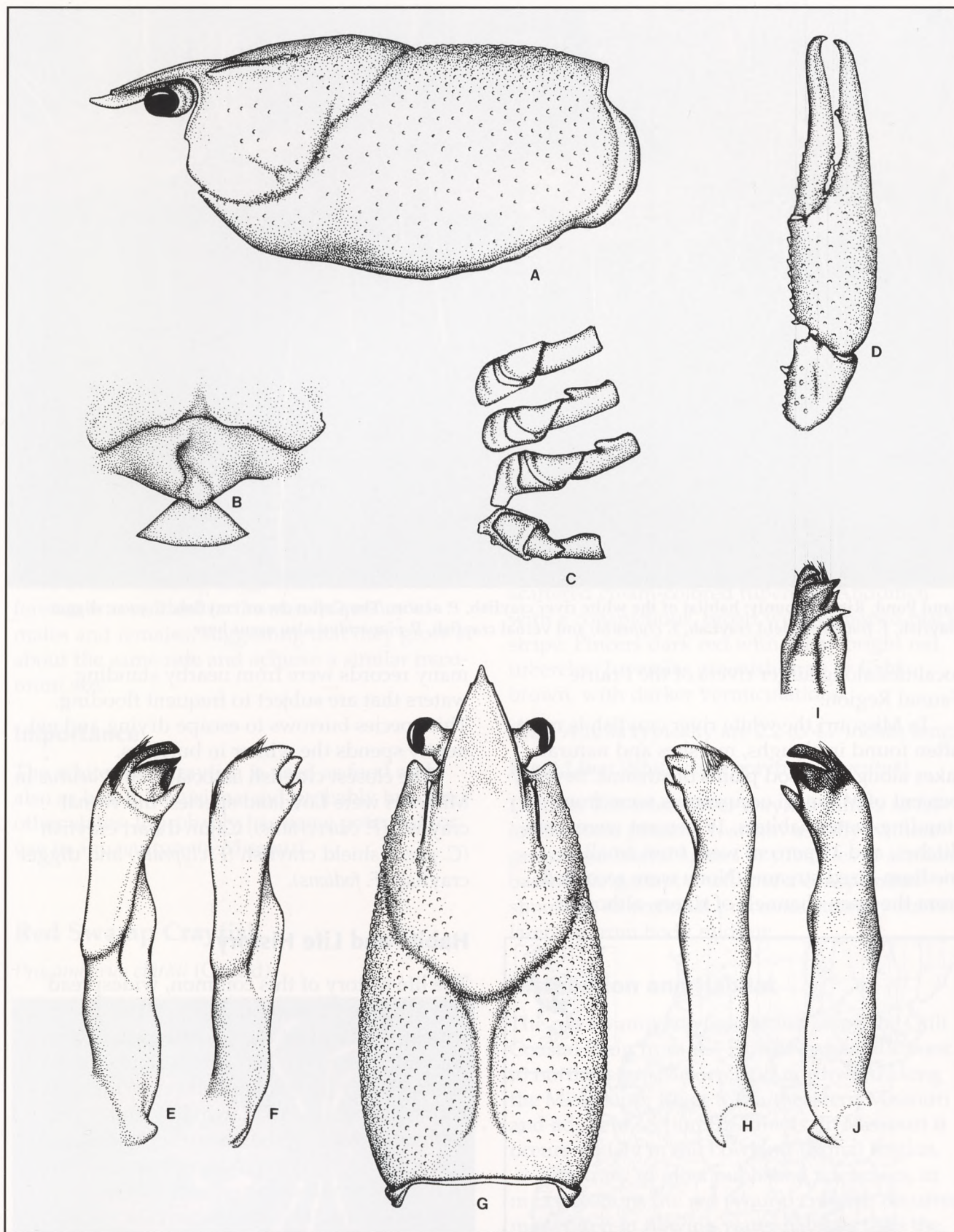


Plate 30. - *Procambarus acutus*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, ventral view of Form I male gonopod; J, lateral view of Form I male gonopod.



Sand Pond, Ripley County; habitat of the white river crayfish, *P. acutus*. The Cajun dwarf crayfish, *C. puer*; digger crayfish, *F. fodiens*; shield crayfish, *F. clypeata*; and vernal crayfish, *P. viaveridus*, also occur here.

localities along larger rivers of the Prairie Faunal Region.

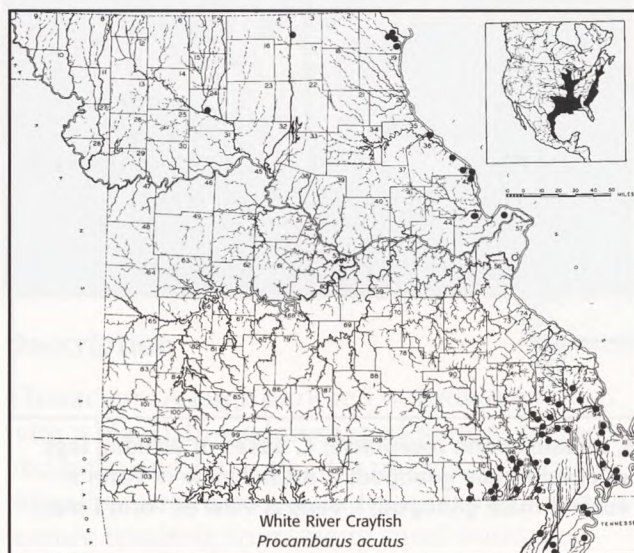
In Missouri the white river crayfish is most often found in sloughs, marshes and natural lakes along the flood plains of streams. Seventy percent of Missouri occurrences were from standing-water habitats, 19 percent were from ditches, and 11 percent were from small to medium-sized streams. None were recorded from the open channels of rivers, although

many records were from nearby standing waters that are subject to frequent flooding. This species burrows to escape drying and evidently spends the winter in burrows.

The closest crayfish associates of *P. acutus* in Missouri were Lowland species: the vernal crayfish (*P. viaveridus*), Cajun dwarf crayfish (*C. puer*), shield crayfish (*F. clypeata*) and digger crayfish (*F. fodiens*).

Habits and Life History

The life history of this common, widespread crayfish is not known in detail. Males and females are thought to pair in the fall before entering burrows, where mating and overwintering occur.⁴⁶ In Ohio, females carrying eggs or young were found in March, July and September, leading the researcher to conclude that *P. acutus* "may reproduce at any season."⁸⁴ In Illinois, females with eggs or young were found in April, July, August and December.⁶⁵ Most females bearing eggs or young were taken from burrows. In Missouri, a female with eggs was observed August 22, 1991, in an area recently flooded by a levee break at the B. K.



Leach Conservation Area, Lincoln County (Tim Grace, pers. comm.). Another female carrying young was caught September 23, 1985, at the Ted Shanks Conservation Area, Pike County (Phil Covington, pers. comm.). I seined a female carrying 303 young from a roadside pool in Stoddard County March 12, 1986.

My collections are insufficient to determine if there are seasonal changes in the frequency of Form I males, as in many other crayfish species. Form I males were found each month from February through June and in November. However, Form II males outnumbered Form I males in many collections. Most studies in other states do not suggest much seasonality in the occurrence of breeding males in *P. acutus*.⁶⁵

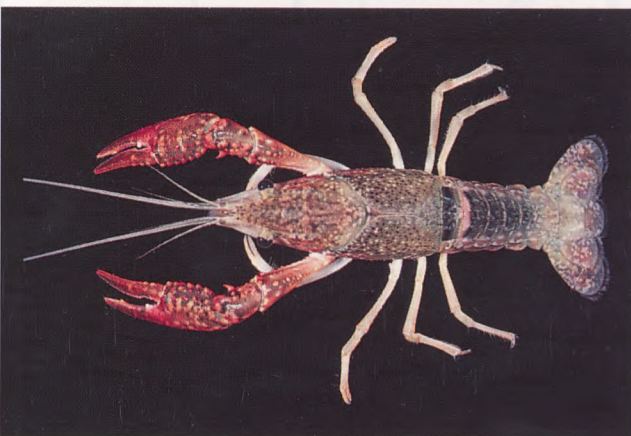
Length-frequency analysis of white river crayfish collected during March indicated the presence of a large group of individuals ranging in length from 0.6 to 1.6 inches with a modal length of 1.2 inches. This length group made up 80 percent of the sample. No additional modes were evident among larger individuals. No difference was evident in the size-frequency of males and females, suggesting that they grow at about the same rate and achieve a similar maximum size.

Importance

The white river crayfish is used as food and also as bait in Louisiana and probably in some other states. It probably has some potential for use in aquaculture in Missouri.

Red Swamp Crayfish

Procambarus clarkii (Girard)



Mingo Swamp, Wayne County

Description

Characters: A large, dark red to nearly black crayfish with long, slender pincers and a blackish wedge-shaped pattern on the abdomen. Carapace laterally compressed, its sides with a granular texture resulting from many small bumps or tubercles. Areola absent. Rostrum with a troughlike central depression, its thickened lateral margins set off by definite tubercles or spines from the acumen. Pincers with many tubercles, the largest along inside margin of palm.

Male gonopod with four short, bladelike terminal processes that do not strongly curve laterally from the midline. Gonopod tip with a prominent shoulder. Hooks present on bases of second and third pairs of walking legs.

Female sperm receptacle without a definite fossa, but with two conspicuous anterior tubercles.

Life Colors: Carapace nearly black except for scattered cream-colored tubercles. Abdomen with a conspicuous, broad wedge-shaped black stripe. Pincers dark red with many bright red tubercles. Juveniles greenish-gray or light brown, with darker vermiculations.

Size: Adults typically are 2.2 to 4.7 inches long.

Most Like: White river crayfish (*P. acutus*).

Differs: The white river crayfish differs as follows: areola present; rostrum usually without prominent lateral spines or tubercles at acumen base; male gonopod without a conspicuous shoulder, its terminal processes strongly curved laterally from body midline.

Distribution and Habitat

The red swamp crayfish occurs along the Gulf Coastal Plain from the Florida panhandle west to northeastern Mexico, and northward along the Mississippi River to southeastern Missouri and adjacent sections of Illinois. In Missouri it occurs widely in the Lowland Faunal Region.

Contrary to most published references, in my collections the red swamp crayfish occurred more often in flowing water habitats than the white river crayfish. Sixty-one percent of Missouri occurrences were from lowland streams and ditches, and 79 percent of these habitats had noticeable current or flow. Other

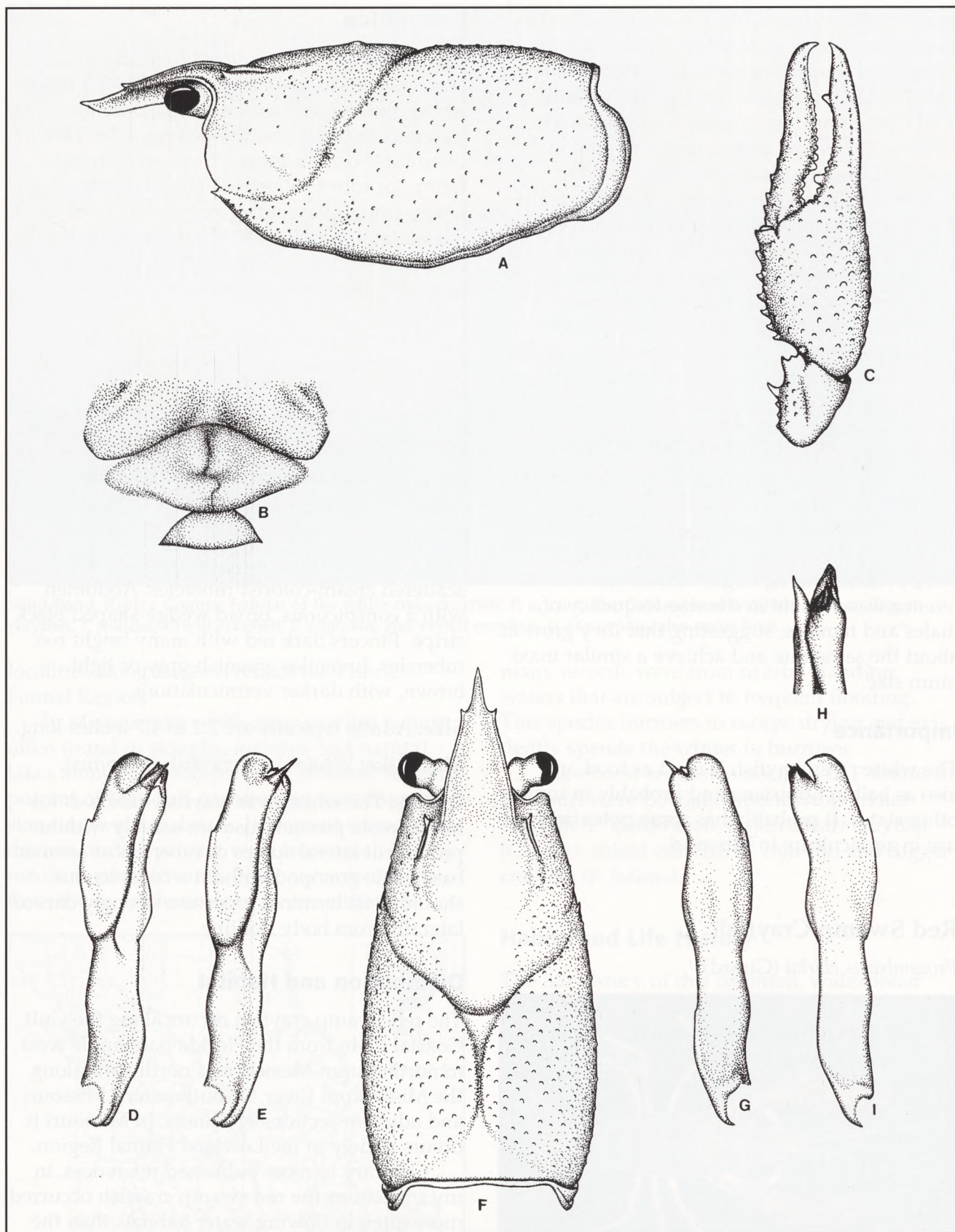
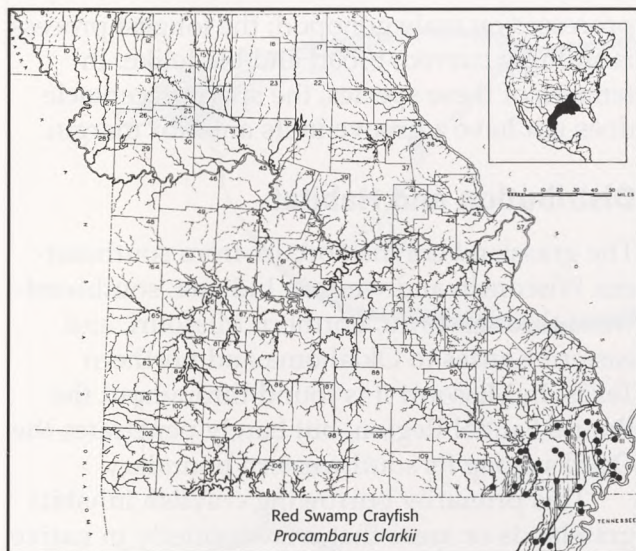


Plate 31. - *Procambarus clarkii*. A, lateral view of carapace; B, female sperm receptacle; C, dorsal view of right pincer; D, mesial view of Form I male gonopod; E, mesial view of Form II male gonopod; F, dorsal view of carapace; G, lateral view of Form II male gonopod; H, ventral view of Form I male gonopod; I, lateral view of Form I male gonopod.



habitats in which the red swamp crayfish occurred were swamps, sloughs and roadside pools. This species was invariably found over a bottom composed of mud or sand, often where there were considerable quantities of organic debris such as logs, sticks or water-soaked tree leaves. Occasionally, thick growths of aquatic vegetation were present, but 52 percent of the occurrences were in habitats where no vegetation was found.

The closest associates of the red swamp crayfish, in order of number of co-occurrences, were the white river crayfish (*P. acutus*), gray-speckled crayfish (*O. palmeri*) and the dwarf crayfishes (*C. puer* and *C. shufeldtii*).

Certain interesting differences were evident between species associations of the red swamp crayfish and the white river crayfish in Missouri. In southeastern Missouri the latter species was frequently recorded in habitats where the digger crayfish (*F. fodiens*), shield crayfish (*F. clypeatus*) and vernal crayfish (*P. viaeveridus*) were found, but the red swamp crayfish was recorded only once in association with *P. viaeveridus*, and never in association with the other two species. The three above-listed species invariably were found only in temporary standing-water habitats, perhaps suggesting a preference of the red swamp crayfish for permanent waters.

Habits and Life History

The red swamp crayfish occurs in burrows during winter and may burrow at other times of the year to escape drying.^{69,43} Some individuals

construct a fairly good chimney, but others simply dump the excavated mud at the mouth of the burrow.⁴³ In Louisiana, breeding may occur whenever mature males and females come together in shallow warm water, but is for the most part restricted to the fall.⁶⁹ Reproduction occurs over an extended period from July to October and sporadically at other times of the year.

Females carrying eggs or young are found in burrows, but also occur in open water, particularly after heavy rains. Eggs hatch about 14 days after laying, and the young may leave the female five days later after completing their second molt. The young appear in the population in large numbers during August to November.

Growth of the red swamp crayfish is most rapid in Louisiana during February, March and April; the population consists mainly of adults during May, June, and July.⁶⁹ Mature males die shortly after breeding in the fall, following a mass migration in some years. Many females also die after reproducing, but some survive to reproduce a second year.

Most Missouri samples of the red swamp crayfish consisted of young collected from December through March. Only four Form I males and no females carrying eggs or young were recorded. In Illinois, a female carrying young was collected in February and five females carrying eggs or young were dug from burrows in September.⁶⁵ Reproduction at the latitude of Missouri probably occurs primarily in burrows during fall and early winter.

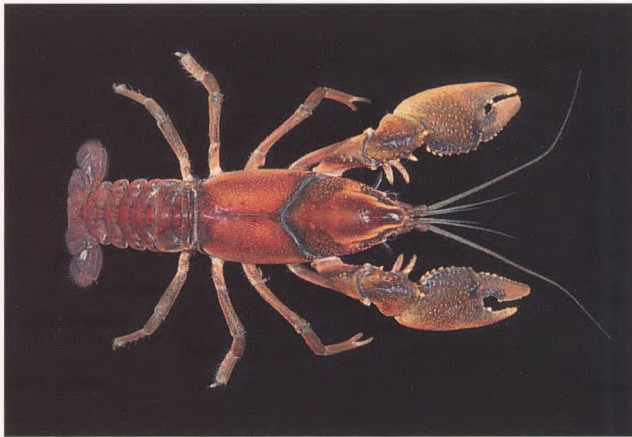
Importance

The red swamp crayfish is the most important crayfish, economically, in North America — with a total harvest from wild and aquacultural sources of more than 50,000 metric tons annually.⁵⁰ Nearly all of this production is from Louisiana. This crayfish has been widely introduced outside its native range in the United States and other countries, and often has become a serious agricultural pest.⁴⁸

In Missouri, the principal value of the red swamp crayfish is as food for various vertebrates living in wetland areas, but it may have some potential as an aquacultural crop in the Missouri "bootheel."

Grassland Crayfish

Procambarus gracilis (Bundy)



Near Millersburg, Callaway County

Description

Characters: A more or less uniformly colored, bright red or reddish brown crayfish of medium size with broad powerful pincers. High, dome-shaped carapace longer than abdomen. Areola absent. Rostrum with a troughlike central depression, its thickened lateral margins converging abruptly into a short acumen without lateral spines or tubercles. Pincers deeply pitted, but without prominent tubercles except along inside margins of fingers and palm. Male gonopod with four short processes, the longest process slender, gently curved, and tapering gradually into a sharp tip. Hooks present only on bases of second pair of walking legs. Female sperm receptacle roundish in outline, with a deep fossa to one side of body midline and with several small tubercles along either side of a shallow groove in its anterior margin.

Life Colors: Body reddish-brown or bright red, without conspicuous spots or blotches. Pincers similar in color to body, but with a greenish cast. Young have a pale central zone on the carapace, and paired lengthwise dark lines or dashes on the abdomen.

Size: Adults are about 2.1 to 2.8 inches long.

Most Like: Superficially resembles devil crayfish (*Cambarus diogenes*) and digger crayfish (*Fallicambarus fodiens*).

Differs: The devil crayfish and digger crayfish have two long, as opposed to four short,

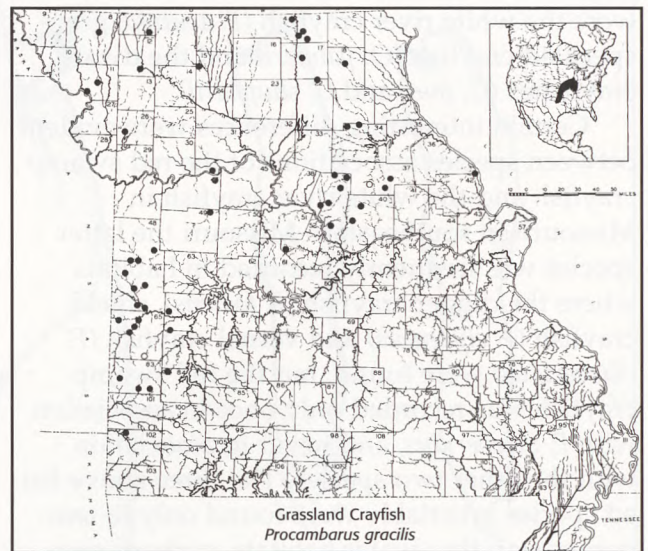
processes on male gonopod; the longest process is strongly curved, broad and bladelike. In females of these species, the sperm receptacle does not have a groove in its anterior margin.

Distribution and Habitat

The grassland crayfish occurs from southeastern Wisconsin and western Indiana, southwestward through Iowa, northern Missouri, and eastern Kansas to Oklahoma and northern Texas. In Missouri it is found throughout the Prairie Faunal Region, but barely penetrates the Ozarks along its southwestern boundary.

This primarily burrowing crayfish inhabits grasslands or areas that were formerly in native grasses where it digs burrows up to six feet or more in depth, often at long distances from permanent water. Juveniles and occasional adults occur in temporary wetlands, ditches and stream channels during seasons when the water table is high.

The grassland crayfish is not closely associated with any other species, but in open waters it occurs occasionally with the northern crayfish (*O. virilis*) and papershell crayfish (*O. immunis*), and rarely with the devil crayfish (*C. diogenes*) and white river crayfish (*P. acutus*).



Habits and Life History

This crayfish remains in its burrow for extended periods, emerging to wander over the landscape primarily on warm nights when the humidity is high.^{90,65} In eastern Oklahoma the grassland crayfish is most active from shortly

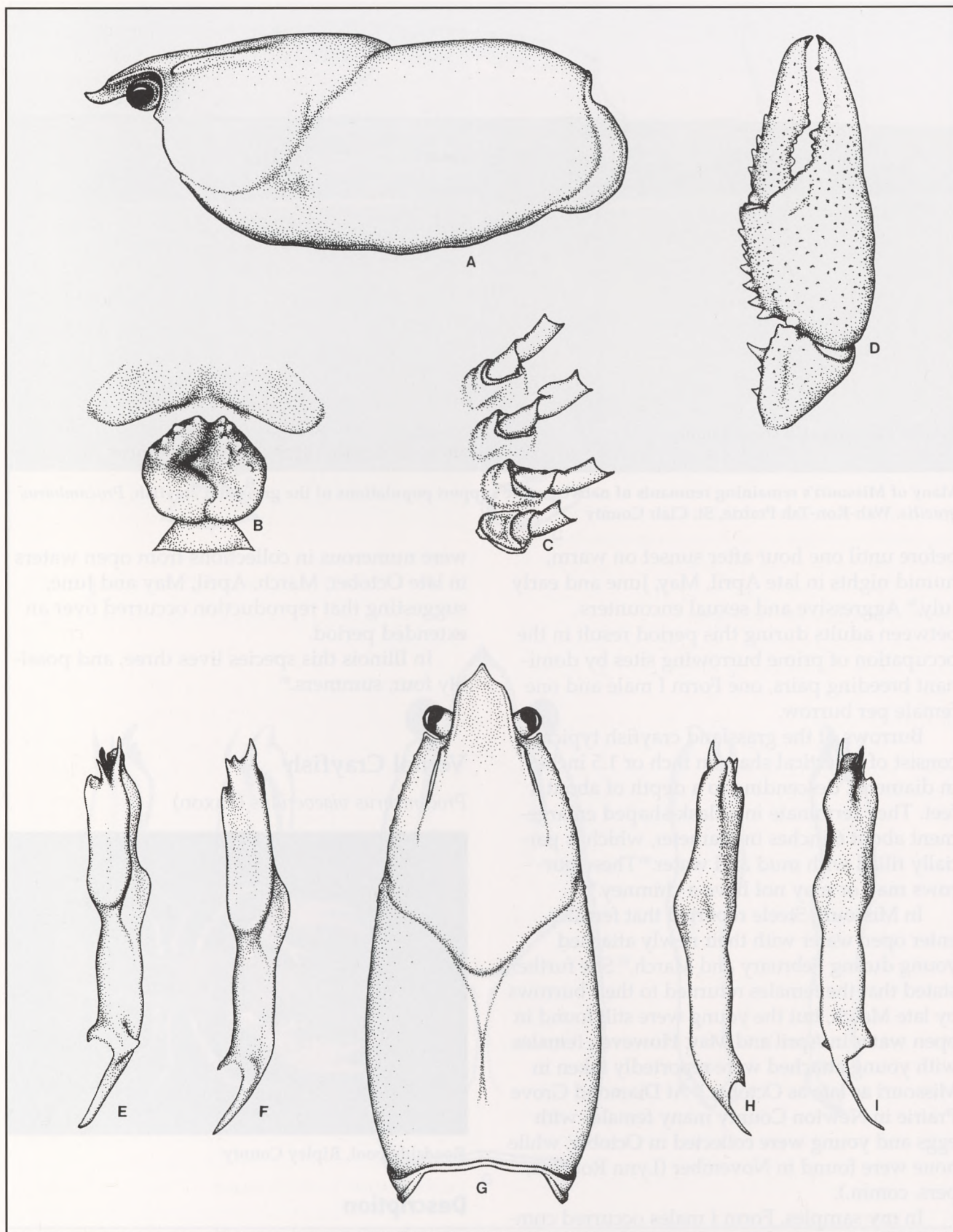


Plate 32. - *Procambarus gracilis*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.



Mark Sullivan

Many of Missouri's remaining remnants of native prairie support populations of the grassland crayfish, *Procambarus gracilis*. Wah-Kon-Tah Prairie, St. Clair County

before until one hour after sunset on warm, humid nights in late April, May, June and early July.³⁶ Aggressive and sexual encounters between adults during this period result in the occupation of prime burrowing sites by dominant breeding pairs, one Form I male and one female per burrow.

Burrows of the grassland crayfish typically consist of a vertical shaft an inch or 1.5 inches in diameter, descending to a depth of about 4 feet. They terminate in a flask-shaped enlargement about 6 inches in diameter, which is partially filled with mud and water.⁸⁰ These burrows may or may not have a chimney.³⁶

In Missouri, Steele reported that females enter open water with their newly attached young during February and March.⁸⁰ She further stated that the females returned to their burrows by late March, but the young were still found in open water in April and May. However, females with young attached were reportedly taken in Missouri as late as October.¹⁵ At Diamond Grove Prairie in Newton County many females with eggs and young were collected in October, while none were found in November (Lynn Robbins, pers. comm.).

In my samples, Form I males occurred commonly in traps set at the entrances of burrows in June, perhaps suggesting a period of increased activity associated with breeding. Juveniles recently dispersed from the females

were numerous in collections from open waters in late October, March, April, May and June, suggesting that reproduction occurred over an extended period.

In Illinois this species lives three, and possibly four, summers.⁶⁵

Vernal Crayfish

Procambarus viantheridus (Faxon)



Roadside pool, Ripley County

Description

Characters: A reddish-brown crayfish of medium size with a blackish wedge-shaped pattern on abdomen. Pincers long and slender with tubercles confined to inner margins of fingers

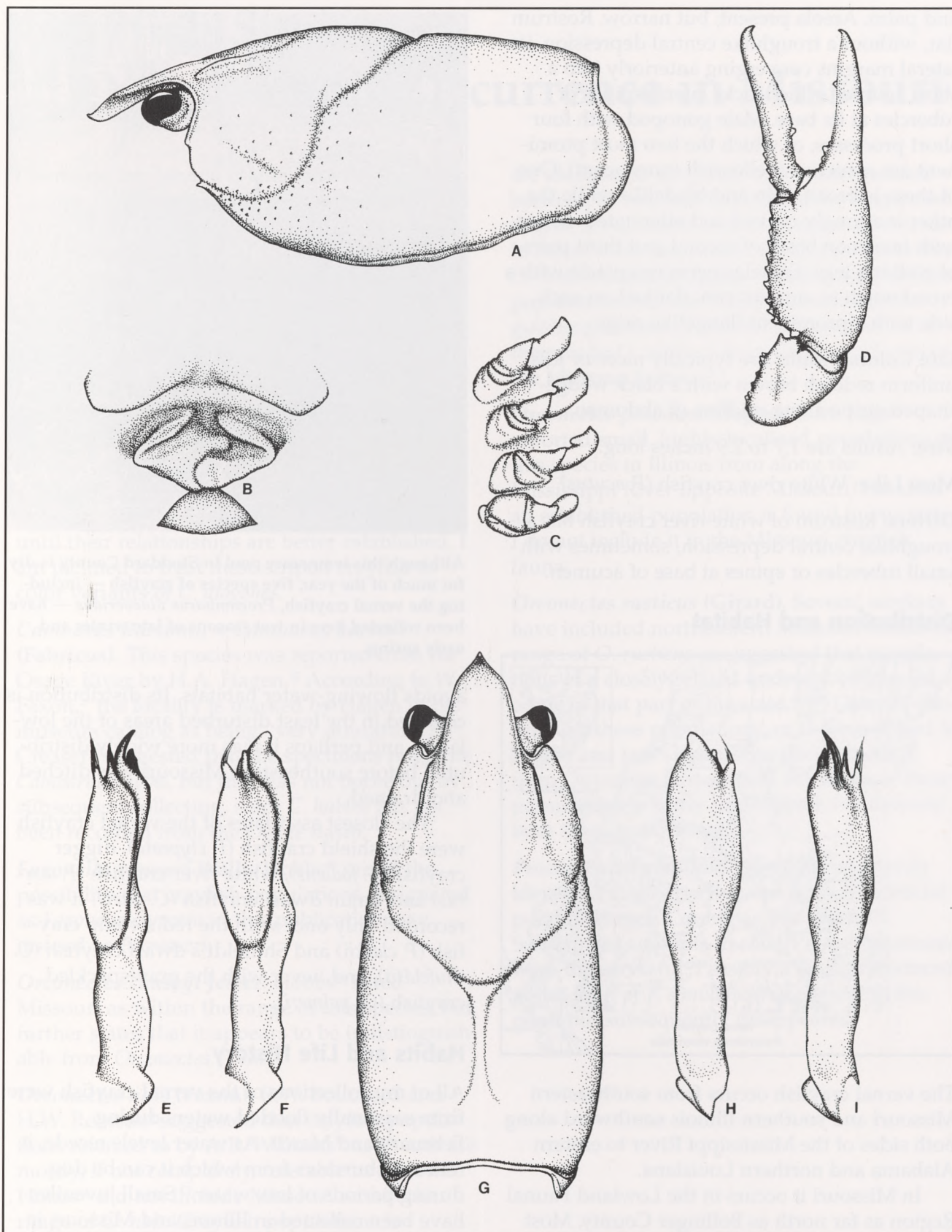


Plate 33. - *Procambarus viaeveridus*. A, lateral view of carapace; B, female sperm receptacle; C, bases of walking legs of Form I male; D, dorsal view of right pincer; E, mesial view of Form I male gonopod; F, mesial view of Form II male gonopod; G, dorsal view of carapace; H, lateral view of Form II male gonopod; I, lateral view of Form I male gonopod.

and palm. Areola present, but narrow. Rostrum flat, without a troughlike central depression, its lateral margins converging anteriorly into a short acumen which lacks lateral spines or tubercles at its base. Male gonopod with four short processes, of which the two most prominent are corneous (yellowish translucent). One of these is broad, thin and bladelike while the other is strongly curved and attenuated. Males with hooks on bases of second and third pairs of walking legs. Female sperm receptacle with a broad notch in anterior rim, flanked on each side with a prominent flangelike ridge.

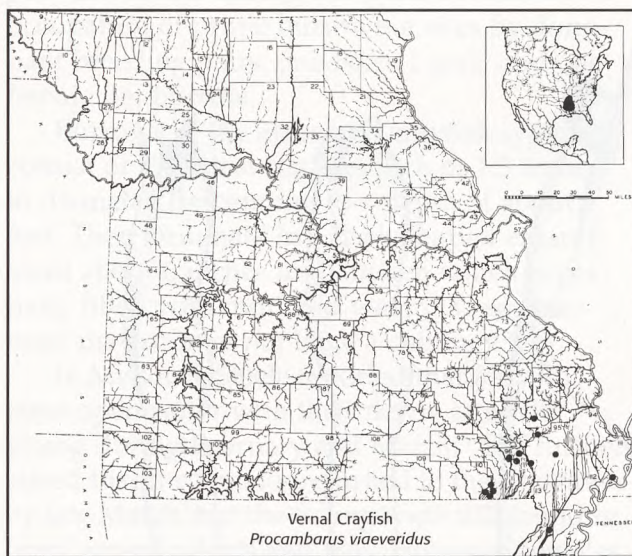
Life Colors: Adults are typically more or less uniform reddish brown with a black wedge-shaped stripe along midline of abdomen.

Size: Adults are 1.7 to 2.9 inches long.

Most Like: White river crayfish (*P. acutus*).

Differs: Rostrum of white river crayfish has a troughlike central depression, sometimes with small tubercles or spines at base of acumen.

Distribution and Habitat



The vernal crayfish occurs from southeastern Missouri and southern Illinois southward along both sides of the Mississippi River to eastern Alabama and northern Louisiana.

In Missouri it occurs in the Lowland Faunal Region as far north as Bollinger County. Most records are concentrated along the Ozark border in Ripley, Butler and Stoddard counties.

This species exhibits an affinity for shallow, seasonally flooded swamps and sloughs, and



Although this temporary pool in Stoddard County is dry for much of the year, five species of crayfish — including the vernal crayfish, *Procambarus viaeveridus* — have been collected here in wet seasons of late winter and early spring.

avoids flowing-water habitats. Its distribution is centered in the least disturbed areas of the lowlands, and perhaps it was more widely distributed before southeastern Missouri was ditched and drained.

The closest associates of the vernal crayfish were the shield crayfish (*F. clypeata*), digger crayfish (*F. fodiens*), white river crayfish (*P. acutus*) and Cajun dwarf crayfish (*C. puer*). It was recorded only once with the red swamp crayfish (*P. clarkii*) and Shufeldt's dwarf crayfish (*C. shufeldtii*), and never with the gray-speckled crayfish (*O. palmeri*).

Habits and Life History

All of my collections of the vernal crayfish were from seasonally flooded waters during February and March. As water levels recede, it retires to burrows from which it can be dug during periods of low water.⁶⁵ Small juveniles have been collected in Illinois and Missouri in January and February, perhaps suggesting that reproduction occurs in the fall. Females carrying eggs or young are unknown. This species is thought to live two years in Illinois.⁶⁵

Crayfish Species of Questionable Occurrence in Missouri

***Cambarus aculabrum* Hobbs and Brown.** Bear Hollow Cave, one of two known localities for this species, is in northern Arkansas very near the Missouri state line; the source for the cave stream supporting this population may actually be in McDonald County, Missouri. The discovery of additional populations of this species in southwestern Missouri is a distinct possibility.

***Cambarus ludovicianus* Faxon.** This crayfish has been variously treated as a color variant of *Cambarus diogenes*,⁴³ as a subspecies,⁶ or as a full species.⁴⁰ If the latter view is correct, the striped *Cambarus* occasionally encountered in southeastern Missouri are *C. ludovicianus*. However, until their relationships are better established, I am inclined to treat these striped crayfish as color variants of *C. diogenes*.

***Cambarus Bartonii*, = *Cambarus bartoni* (Fabricus).** This species was reported from the Osage River by H.A. Hagen.³² According to W. Faxon,²¹ the locality is marked by Hagen in the museum catalog as being "very doubtful." E.P. Creaser¹³ suggested that the specimens might be *Cambarus hubbsi*, but this was not borne out by subsequent collecting, since *C. hubbsi* has not been recorded from the Osage Basin.

***Faxonella creaseri* Walls.** Hobbs⁴⁰ raised the possibility that crayfish populations designated as *Faxonella clypeata* in this publication may instead be *F. creaseri*.

***Orconectes causeyi* Jester.** Hobbs⁴⁰ listed Missouri as within the range of this species, but further states that it appears to be indistinguishable from *Orconectes virilis*.

***Orconectes nais* (Faxon).** R.W. Bouchard and H.W. Robison⁶ suggested that crayfish populations referred to by A.B. Williams⁸⁹ as *O. nais* are mostly, if not completely, referable to *O. virilis*. Hobbs⁴⁰ did not include Missouri within the range of *O. nais*. Crayfish populations in streams north of the Missouri River, from Little Bonne Femme Creek in Boone County eastward to Loutre River in Montgomery County, and from scattered localities elsewhere in the state,

are identifiable as *O. nais* or are intermediate between *O. nais* and *O. virilis* in the length and degree of curvature of male gonopod processes. In other ways they seem indistinguishable from *O. virilis*. Considering the intermediacy of these populations and the absence of other distinguishing features, I tentatively consider all of them to be *O. virilis*. I do not include *O. nais* in the Missouri fauna.

***Orconectes placidus* (Hagen).** L.M. Page⁶⁵ reported small, highly localized populations of this species in Illinois from along the Mississippi River opposite Missouri, but until an established population is found in our state, I do not include it in the Missouri crayfish fauna.

***Orconectes rusticus* (Girard).** Several workers have included northeastern Missouri within the range of *O. rusticus* or suggested that populations of a closely related undescribed species occur in that part of the state.^{46,66,73} I cannot distinguish these populations, or those mapped by Hobbs and Jass⁴⁶ in southwestern Missouri, from *Orconectes luteus*. Until the status of these populations is better understood, I tentatively treat them as *O. luteus*.

***Procambarus simulans* (Faxon).** I tentatively identified two Form II males from an artificial pond in Vernon County as this species. Subsequent attempts to collect more specimens were unsuccessful. Possibly a small introduced population of *P. simulans* was present in this pond but subsequently disappeared.

Historical Review of Published References to Missouri Crayfish Fauna

The earliest references to crayfish in Missouri were incidental to studies of the North American fauna in the late 19th century by H. A. Hagen³² and W. Faxon.^{20,21,22,23} These authors did not themselves collect in Missouri, but rather based their descriptions and reports on specimens sent from Missouri to museums in the East by collectors. Because the study of North American crayfish was still in its infancy, the names used by these workers would not, in many instances, be appropriate today.

However, based on these early reports, we can confidently assign the following 11 species to the known crayfish fauna of Missouri prior to 1900: *Cambarus diogenes*, *Cambarus setosus*, *Orconectes harrisoni*, *Orconectes hylas*, *Orconectes luteus*, *Orconectes medius*, *Orconectes neglectus*, *Orconectes punctimanus*, *Orconectes virilis*, *Procambarus acutus* and *Procambarus gracilis*. Four of these species were described by Faxon as new, based on specimens from Missouri: *Cambarus setosus*, *Orconectes harrisoni*, *Orconectes hylas* and *Orconectes medius*.

The description of *Cambarus setosus* by Faxon²¹ is based on specimens collected by Miss Ruth Hoppin from wells and caves in the vicinity of Sarcxie, Jasper County. Her observations of crayfish and other subterranean life forms are quoted at length by S. Garman²⁷ from letters that accompanied specimens provided to him by Miss Hoppin.

The report by M. Steele⁸⁰ represents the earliest attempt to treat the Missouri crayfish fauna as a whole. She compiled previous reports from the literature, provided some new locality records, described as new species *Cambarus ayersii* (= *Cambarus setosus*) and *Cambarus whitmani* (= *Orconectes longidigitus*), and reported her observations on the biology of *Procambarus gracilis* and early development and morphological variation in *Orconectes virilis*. She added two species, *Orconectes immunis* and *Orconectes longidigitus*, to the known crayfish fauna of Missouri.

I have been unsuccessful in assigning her report of *Cambarus hayi* (= *Procambarus hayi*)

from the James River to any crayfish species known to occur in Missouri.

J. A. Harris^{33,34} and Faxon²⁴ provided additional records for crayfish in Missouri, but did not add to the known fauna of 13 species.

A considerable period of time elapsed before E. P. Creaser^{13,16,17} provided the original descriptions of *Cambarus hubbsi*, *Orconectes luteus*, *Orconectes peruncus*, *Orconectes punctimanus* and *Orconectes quadruncus* from Missouri. He also compiled numerous distribution records for these species and also for *Orconectes harrisoni*, *Orconectes hylas* and *Orconectes medius*.

L. Hubricht⁴⁷ reported an undescribed species of cave crayfish from Lewis Cave in Ripley County. These specimens were subsequently described as *Cambarus hubrichti* by H. H. Hobbs, Jr.³⁷ P. H. Wells and A. Witt, Jr.⁸⁷ provided additional locality records for *C. hubrichti*.

One of the most important contributors to knowledge about Missouri crayfish was A. B. Williams.^{88,89} From specimens collected in Missouri, he described as new *Orconectes eupunctus*, *Orconectes macrus* and *Orconectes neglectus chaenodactylus*. For 20 species and subspecies of crayfish, he compiled and mapped extant distribution records from the Ozark Region of Missouri, and provided descriptions, illustrations and keys for identifying them.

Most subsequent publications have dealt with Missouri crayfish as part of broader treatments of the North American crayfish fauna,^{38,39,40} or in depth with a restricted taxonomic group such as the cave-dwelling *Cambarus*.^{41,42,56} J. E. Gardner²⁶ provided distributional records for both cave-adapted and stream-adapted crayfish species from Missouri caves and springs.

W. L. Pflieger⁷² provided photographs, brief descriptions, and general distributional information for 28 species of Missouri crayfish. H. H. Hobbs, Jr. and Pflieger⁴⁴ described *Cambarus maculatus* from Hazel Creek, Washington County, and mapped distribution records for that species and *Cambarus hubbsi*.

The most recent compilation of North American crayfish taxa by Hobbs⁴⁰ lists 33

Nominal Crayfish Taxa Described from Missouri

Name Proposed	Identification	Type Locality	Disposition of Types	Literature Citation
<i>Cambarus ayersii</i>	<i>Cambaris setosus</i>	Fisher's Cave (Sequoiata Cave) near Springfield, Green Co.	USNM62316	Steele 1902:18
<i>Cambarus (Bartonius) hubbsi</i>	<i>Cambarus hubbsi</i>	Little Cr. NE of Chloride, Iron Co.	USNM98332,98333	Creaser 1931a:4
<i>Cambarus hubrichti</i>	<i>Cambarus hubrichti</i>	Lewis (Fishers) Cave NW of Doniphan, Ripley Co.	USNM92295,92296	Hobbs 1952:689
<i>Cambarus (Eribicambarus) maculatus</i>	<i>Cambarus maculatus</i>	Hazel Cr. NE of Courtois, Washington Co.	USNM219292,219293, 219280	Hobbs and Pflieger 1988:644
<i>Cambarus setosus</i>	<i>Cambarus setosus</i>	Wilson's Cave NW of Sarcoxie, Jasper Co.	MCZ4200,4201,4202; USNM25828	Faxon 1889:237
<i>Orconectes (Sic) eupunctus</i>	<i>Orconectes eupunctus</i>	Eleven Point R. at Riverton, Oregon Co.	USNM129200	Williams 1952:330
<i>Cambarus harrisonii</i>	<i>Orconectes harrisoni</i>	Irondale, Washington Co.	MCZ3586,USNM25826	Faxon 1884:130
<i>Cambarus hylas</i>	<i>Orconectes hylas</i>	W. Fork Black R., Reynolds Co.	MCZ3858,USNM25827	Faxon 1890:632
<i>Faxonius luteus</i>	<i>Orconectes luteus</i>	Niangua R. SE of Buffalo, Dallas Co.	USNM98344,98345	Creaser 1933:7
<i>Orconectes nana macrus</i>	<i>Orconectes macrus</i>	Spring R. SW of Mt. Vernon, Lawrence Co.	USNM118847	Williams 1952:337
<i>Cambarus Whitmani</i>	<i>Orconectes longidigitus</i>	James R.	Unknown	Steele 1902:24
<i>Cambarus medius</i>	<i>Orconectes medius</i>	Irondale, Washington Co.	MCZ3585	Faxon 1884:121
<i>Orconectes neglectus chaenodactylus</i>	<i>Orconectes neglectus chaenodactylus</i>	White Cr. SE of Ava, Douglas Co.	USNM118840	Williams 1952:344
<i>Cambarus (Faxonius) peruncus</i>	<i>Orconectes peruncus</i>	Little Cr. NE of Chloride, Iron Co.	USNM98339,98340	Creaser 1931a:7
<i>Faxonius punctimanus</i>	<i>Orconectes punctimanus</i>	Roubidoux Cr. at Waynesville, Pulaski Co.	USNM98342,98343	Creaser 1933:1
<i>Faxonius quadruncus</i>	<i>Orconectes quadruncus</i>	Stouts Cr. between Ironton and Arcadia, Iron Co.	USNM98346,98347	Creaser 1933:10

species and subspecies for the state of Missouri.

Fifteen species and one subspecies of crayfish have been named and described from speci-

mens collected in Missouri (see table above). All but two of these taxa are still considered to be valid.

A Glossary of Technical Terms

Abdomen — The posterior, externally segmented part of the crayfish body.

Abdomen length — Distance from hind margin of carapace to end of tail fan, exclusive of any bristles that may be present.

Acumen — The narrow, spinelike forward extension of the rostrum.

Acumen length — Distance from tip of acumen to its base.

Annulus ventralis — See sperm receptacle.

Antennae — The longest of two sets of segmented filaments or "feelers" present on the front of the head.

Antennal scales — A pair of bladelike structures, each terminating in a spine, extending forward from beneath the eyes.

Antennules — The shortest of two sets of segmented filaments or "feelers" present on the front of the head. Each antennule consists of two filaments.

Anterior — Situated forward, or towards the head.

Appendage — Any segmented projection from the head or body, such as the antennae or legs.

Areola — An hourglass-shaped area situated along the midline of the carapace between the cervical groove and abdomen. Its lateral margins are defined by a pair of shallow concave grooves. When these grooves touch for part of their length, the areola is said to be absent.

Areola length — Distance from cervical groove to hind margin of carapace at carapace midline.

Areola width — Distance across areola at its narrowest point.

Body length — Distance from tip of rostrum to end of tail fan.

Carapace — A dome-shaped, unsegmented shell covering the anterior half of the body.

Carapace height — The greatest vertical distance between upper margin and lower margin of carapace.

Carapace length — Distance from tip of acumen to posterior margin of carapace.

Carapace width — The distance across the carapace at its widest point.

Carina — A low ridge or raised area along the midline of the rostrum between the eyes.

Cervical groove — A shallow, transverse groove separating the head from the rest of the carapace.

Chelipeds — The most anterior and largest of five pairs of legs extending from beneath the carapace. Each cheliped terminates in an enlarged claw or pincer.

Chiten — The material comprising the rigid external skeleton or shell of crayfish.

Concave — Curved inward, toward the midline of the body.

Convex — Curved outward, away from the midline of the body.

Corneous — With reference to the gonopod processes, having a yellowish translucent texture that contrasts with the whitish opaque appearance of the rest of the gonopod.

Dorsal — Pertaining to the upper body surface or back.

Epistome — A small, tonguelike structure located ventrally on the head between the bases of the antennules.

Exoskeleton — The more or less rigid external covering of crayfish and other arthropods.

Fixed finger — The finger that is fused immovably to the base of the pincer.

Form I male — An adult male crayfish that is capable of breeding, as indicated by the presence of a corneous (yellowish translucent) tip on one or more of the gonopod processes.

Form II male — An adult male crayfish that is incapable of breeding, as indicated by absence of corneous (yellowish translucent) tips on any of the gonopod processes.

Fossa — A shallow depression on the ventral

surface of the sperm receptacle in female crayfish.

Gonopod length — Distance from base of gonopod to the tip of the longest gonopod process.

Gonopod processes — The terminal elements of the male gonopod. Among Missouri species, the number of processes on the gonopod ranges from four in species of the genus *Procambarus*, to three in the genus *Cambarellus*, to two in the genera *Cambarus*, *Fallicambarus*, *Faxonella* and *Orconectes*.

Gonopods — A pair of structures extending forward between the bases of the walking legs from their point of attachment to the ventral surface of the first abdominal segment in male crayfish. The gonopods in adult males exhibit a cyclic dimorphism associated with reproduction. Breeding (Form I) males are distinguished by the presence of a corneous (yellowish translucent) tip on one or more of the gonopod processes. In non-breeding (Form II) males, the tips of the gonopod processes are blunter and are entirely of a whitish opaque texture.

Head — The part of the carapace anterior to the cervical groove.

Instar — The life history stage of a crayfish between successive molts, the first instar being the stage between hatching and the first molt.

Lateral — To the right or left side.

Lateral spines — Spines at the base of the acumen, setting it off from the rest of the rostrum.

Mesial — The side of the gonopod process facing the body midline.

Palm — The basal part of the pincer.

Pincer — The terminal claw of the most anterior pair of legs extending from beneath the carapace.

Pincer width — The greatest distance across the basal part of the pincer.

Posterior — Situated toward the rear or tail end.

Primary process — In crayfish of the genera *Cambarus*, *Fallicambarus*, *Faxonella* and *Orconectes*, the larger of two tips or points on the male gonopod. The primary process is composed partly of a corneous (yellowish translucent) material in Form I males.

Primary process length — The straightline distance from the base of the primary process to its tip.

Rostrum — A triangular-shaped anterior extension of the carapace, located dorsally between the eyes.

Rostrum length — Distance from base of rostrum to its tip.

Saddle mark — A dark transverse band present on the carapace in some crayfish. Typically, saddle marks occur near the cervical groove and near the junction of the carapace and abdomen.

Secondary process — In crayfish of the genera *Cambarus*, *Fallicambarus*, *Faxonella* and *Orconectes*, the smaller of two tips or points on the male gonopod. In nearly all species, the secondary process is not composed partly of a corneous (yellowish-translucent) material in Form I males.

Setae — Hairlike bristles, such as are evident on the pincers of some crayfish.

Sperm plug — A gummy material deposited by the male crayfish on the sperm receptacle of the female at the time of mating. Its function is to retain the sperm until fertilization, and perhaps to prevent mating with other males.

Sperm receptacle — A pocketlike, raised structure located on the underside of female crayfish between the bases of the last two pairs of walking legs. Technically referred to as the *annulus ventralis*.

Spine — A hard, pointed outgrowth such as frequently occurs on the rostrum or lateral margin of the carapace.

Tail fan — The flattened posterior section of the abdomen in crayfish, technically referred to as the *telson*.

Thorax — The central part of the crayfish body between the cervical groove and the abdomen.

Tubercle — A low knoblike outgrowth such as may be present on the pincer.

Ventral — Pertaining to the lower body surface.

Walking legs — The four pairs of appendages extending laterally from beneath the carapace behind the pincers or chelipeds.

References Cited

1. Aiken, D. E. 1968. The crayfish *Orconectes virilis*: Survival in a region with severe winter conditions. Canadian Jour. Zool. 46:207-211.
2. Ameyaw-Akumfi, C. 1976. Some aspects of the breeding biology of crayfish. Ph.D. thesis, Univ. Michigan, 252 pp.
3. Black, J. B. 1966. Cyclic male reproductive activities in the dwarf crawfishes *Cambarellus shufeldti* (Faxon) and *Cambarellus puer* (Hobbs). American Microscop. Soc. Trans. 85(2):214-232.
4. Black, J. B. 1972. Life history notes on the crawfish *Orconectes lancifer*. Louisiana Acad. Sci. Proc. 35:7-9.
5. Bouchard, R. W. 1978. Taxonomy, distribution and general ecology of the genera of North American crayfishes. Fisheries 3(6):11-19.
6. Bouchard, R. W. and H. W. Robison. 1980. An inventory of the decapod crustaceans (crayfishes and shrimps) of Arkansas with a discussion of their habitats. Arkansas Acad. Sci. Proc. 34:22-30.
7. Bovbjerg, R. V. 1952. Comparative ecology and physiology of the crayfish *Orconectes propinquus* and *Cambarus fodiens*. Physiol. Zool. 25:34-56.
8. Bovbjerg, R. V. 1970. Ecological isolation and competitive exclusion in two crayfish (*Orconectes virilis* and *Orconectes immunis*). Ecology 51:225-236.
9. Burbanck, W. D., J. P. Edwards, and M. P. Burbanck. 1948. Toleration of lowered oxygen tension by cave and stream crayfish. Ecology 27(3):360-367.
10. Caldwell, M. J. and R. V. Bovbjerg. 1969. Natural history of the two crayfish of northwestern Iowa, *Orconectes virilis* and *O. immunis*. Iowa Acad. Sci. Proc. 76:463-472.
11. Carpenter, M. B. and R. DeRoos. 1970. Seasonal morphology and history of the androgenic gland of the crayfish, *Orconectes nais*. Gen. and Compar. Endocrinology 15(1):143-157.
12. Covington, W. G. 1982. Smallmouth bass populations in the Ozark National Scenic Riverways. M. S. Thesis, Univ. Missouri, Columbia. 77 pp.
13. Creaser, E. P. 1931a. Three new crayfishes (*Cambarus*) from Puebla and Missouri. Occ. Pap. Mus. Zool. Univ. Michigan 224:1-10.
14. Creaser, E. P. 1931b. Some cohabitants of burrowing crayfish. Ecology 12(1):243-244.
15. Creaser, E. P. 1932. The decapod crustaceans of Wisconsin. Wisconsin Acad. Sci. Trans. 27:321-338.
16. Creaser, E. P. 1933. Descriptions of some new and poorly known species of North American crayfishes. Occ. Pap. Mus. Zool. Univ. Michigan 275:1-23.
17. Creaser, E.P. 1934. A faunistic area of five isolated species of crayfish in southeastern Missouri. Occ. Pap. Mus. Zool. Univ. Michigan 278:1-8.
18. Crunkilton, R. 1982. Bitter harvest. Missouri Conservationist 43(11):4-7.
19. Faxon, W. 1884. Descriptions of new species of *Cambarus*, to which is added a synonymical list of the known species of *Cambarus* and *Astacus*. Proc. American Acad. Arts and Sci. 20:107-158.
20. Faxon, W. 1885. A revision of the Astacidae. Part 1. The genera *Cambarus* and *Astacus*. Harvard Mus. Compar. Zool., Bull. 10(4):1-86.
21. Faxon, W. 1889. *Cambarus setosus* Faxon (p. 237, In: Cave animals from southwestern Missouri, by S. Garman). Harvard Mus. Compar. Zool. Bull. 17(6):225-240.
22. Faxon, W. 1890. Notes on North American crayfishes, Family Astacidae. Proc. U.S. National Mus. 12(785):619-634.
23. Faxon, W. 1898. Observations on the Astacidae in the United States National Museum and in the Museum of Comparative Zoology, with descriptions of new species. Proc. U.S. Nat. Museum, 22(1136):643-694.
24. Faxon, W. 1914. Notes on the crayfishes in the United States National Museum and the Museum of Comparative Zoology with descrip-

tions of new species and subspecies to which is appended a catalogue of the known species and subspecies. Mem. Mus. Compar. Zool., Harvard College 40(8):347-427.

25. Fitzpatrick, J. F. 1966. A new crawfish of the genus *Orconectes* from the headwaters of the White River in Arkansas. Proc. Biol. Soc. Washington 79(21):145-150.

26. Gardner, J. E. 1986. Invertebrate fauna from Missouri caves and springs. Missouri Dept. Conserv. Publ., 72 pp.

27. Garman, S. 1889. Cave animals from southwestern Missouri. Bull. Harvard Mus. Compar. Zool. 17(6):225-240.

28. Girard, C. 1852. A revision of the North American Astaci, with observations on their habits and geographical distribution. Proc. Acad. Nat. Sci. 6:87-91.

29. Grow, L. 1981. Burrowing behavior in the crayfish, *Cambarus diogenes diogenes* (Girard). Animal Behavior 29:351-356.

30. Grow, L. 1982. Burrowing/soil-texture relationships in the crayfish *Cambarus diogenes diogenes* Girard (Decapoda, Astacidae). Crustaceana 42(2):150-157.

31. Grow, L. and H. Merchant. 1980. The burrow habitat of the crayfish *Cambarus diogenes diogenes* (Girard). American Midl. Nat. 103(2):231-236.

32. Hagen, H. A. 1870. Monograph of the North American Astacidae, In: Harvard Mus. Compar. Zool. Illus. Cat. No. 3., 109 pp.

33. Harris, J. A. 1902. Distribution of Kansas crayfishes. Kansas Univ. Sci. Bull. 1(1):1-11.

34. Harris, J. A. 1903. An ecological catalogue of the crayfishes belonging to the genus *Cambarus*. Kansas Univ. Sci. Bull. 2(3):51-187.

35. Hart, C. W., Jr. and J. Clark. 1989. An interdisciplinary bibliography of freshwater crayfishes. Smithsonian Institution Press, 498 pp.

36. Hayes, W. A., II. 1975. Behavioral components of social interactions in the crayfish *Procambarus gracilis* (Bundy) (Decapoda, Cambaridae). Proc. Oklahoma Acad. Sci. 55:1-5.

37. Hobbs, H. H., Jr. 1952. A new albinistic crayfish of the genus *Cambarus* from southern

Missouri, with a key to the albinistic species of the genus (Decapoda, Astacidae). American Midl. Nat. 48(3):689-693.

38. Hobbs, H. H., Jr. 1972. Crayfishes (Astacidae) of North and Middle America, In: Biota of Freshwater Ecosystems. Identification Manual 9, 173 pp.

39. Hobbs, H. H., Jr. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithsonian Contr. Zool. 166:1-161.

40. Hobbs, H. H., Jr. 1989. An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). Smithsonian Contr. Zool. 480:1-236.

41. Hobbs, H. H., Jr. and T. C. Barr. 1960. The origins and affinities of the troglobitic crayfishes of North America (Decapoda, Astacidae). I. The Genus *Cambarus*. American Midl. Nat. 64(1):12-33.

42. Hobbs, H. H., Jr. H. H. Hobbs III, and M. A. Daniel. 1977 A review of the troglobitic decapod crustaceans of the Americas. Smithsonian Contr. Zool. 244:1-183.

43. Hobbs, H. H., Jr. and L. L. Marchand. 1943. A contribution toward a knowledge of the crayfishes of the Reelfoot Lake area. Jour. Tennessee Acad. Sci. 8(1):6-35.

44. Hobbs, H. H., Jr. and W. L. Pflieger. 1988. *Cambarus (Eribicambarus) maculatus*, a new crayfish (Decapoda: Cambaridae) from the Meramec River Basin of Missouri. Proc. Biol. Soc. Washington 101(3):644-652.

45. Hobbs, H. H., Jr. and H. W. Robison. 1989. On the crayfish genus *Fallicambarus* (Decapoda: Cambaridae) in Arkansas, with notes on the *fodiens* complex and descriptions of two new species. Proc. Biol. Soc. Washington 102(3):651-697.

46. Hobbs, H. H., III and J. P. Jass. 1988. The crayfishes and shrimp of Wisconsin (Cambaridae, Palaemonidae). Milwaukee Public Mus. Spec. Publ. Biol. and Geol. No. 5:1-177.

47. Hubricht, L. 1950. The invertebrate fauna of Ozark caves. Nat. Speleol. Soc. Bull. 12:16-17.

48. Huner, Jay V. 1977. Introductions of the Louisiana red swamp crawfish, *Procambarus*

- clarkii* (Girard); an update. Pp. 193-202, In: Freshwater Crayfish. Papers from the Third International Symposium on freshwater crayfish, O. V. Lindquist (Ed). Kuopio, Finland.
49. Huner, J. V. 1978. Exploitation of freshwater crayfishes in North America. Fisheries 3(6):2-5.
 50. Huner, J. V. 1993. International crayfish production. Int. Assoc. Astacology Newsletter 15(1):4.
 51. Korschgen, L. J. and D. L. Moyle. 1955. Food habits of the bullfrog in central Missouri farm ponds. American Midl. Nat. 54(2):332-341.
 52. Korschgen, L. J. and T. S. Baskett. 1963. Foods of impoundment- and stream-dwelling bullfrogs in Missouri. Herpetology 19(2):89-99.
 53. Lorman, J. G. and J. J. Magnuson. 1978. The role of crayfish in aquatic ecosystems. Fisheries 3(6):8-10.
 54. Lowe, M. E. 1956. Dominance-subordinance relationships in the crawfish *Cambarellus shufeldtii*. Tulane Stud. Zool. 4:139-170.
 55. Lowe, M. E. 1961. The female reproductive cycle of the crayfish *Cambarellus shufeldtii*: the influence of environmental factors. Tulane Stud. Zool. 8:157-176.
 56. Marquart, D. 1979. The troglobitic crayfish of Missouri. M. S. Thesis, Central Missouri State Univ.-Warrensburg. 39 pp.
 57. Marteney, R. E. 1983. Rock bass populations in the Ozark National Scenic Riverways. M. S. Thesis, Univ. Missouri-Columbia. 94 pp.
 58. Mohr, C. E. 1950. Ozark cave life. Nat. Speleol. Soc. Bull. 12:3-11.
 59. Momot, W. T. 1967. Population dynamics and productivity of the crayfish, *Orconectes virilis*, in a marl lake. American Midl. Nat. 78(1):55-81.
 60. Momot, W. T., H. Gowing, and P. T. Jones. 1978. The dynamics of crayfish and their role in ecosystems. American Midl. Nat. 99(1):10-35.
 61. Muck, J. A. and C. F. Rabeni. 1993. Comparative reproductive characteristics of three crayfish species from a Missouri Ozark stream. Bull. American Benth. Soc. 10(1):211.
 62. Nickerson, M. A. and C. E. Mays. 1973. The hellbenders. Milwaukee Public Mus., Publ. in Biol. and Geol. No 1., 106 pp.
 63. Norrocky, M. J. 1984. Burrowing crayfish trap. Ohio Jour. Sci. 84(1):65-66.
 64. Norrocky, M. J. 1991. Observations of the ecology, reproduction and growth of the burrowing crayfish *Fallicambarus (Creaserinus) fodiens* (Decapoda: Cambaridae) in North-Central Ohio. American Midl. Nat. 125(1):75-86.
 65. Page, L. M. 1985. The crayfishes and shrimps (Decapoda) of Illinois. Illinois Nat. Hist. Surv. Bull. 33(4):335-448.
 66. Page, L.M., and B.M. Burr 1973. Distributional records for the crayfishes *Cambarellus puer*, *C. shufeldtii*, *Procambarus gracilis*, *P. viaeviridis*, *Orconectes lancifer*, *O. bisectus*, and *O. rusticus*. Trans. Kentucky Acad. Sci. 34:51-52.
 67. Payne, J. F. and J. O. Price. 1983. Studies of the life history and ecology of *Orconectes palmeri palmeri* (Faxon). Pp. 183-191, In: Fifth Int. Symp. on Freshwater Crayfish, C. R. Goldman (Ed.). AVI Publishing Co., Inc.
 68. Penn, G. H. 1942. Observations on the biology of the dwarf crawfish *Cambarellus shufeldtii* (Faxon). American Midl. Nat. 28(3):644-647.
 69. Penn, G. H. 1943. A study of the life history of the Louisiana red-crawfish, *Cambarus clarkii* (Girard). Ecology 24(1):1-18.
 70. Penn, G. H. 1950. The genus *Cambarellus* in Louisiana (Decapoda, Astacidae). American Midl. Nat. 44:421-426.
 71. Penn, G. H. and J. F. Fitzpatrick. 1963. Interspecific competition between two sympatric species of dwarf crawfishes. Ecology 44(4):793-797.
 72. Pflieger, W.L. 1987. An introduction to the crayfish of Missouri. Missouri Conserv., 48(4):17-31.
 73. Phillips, G. S. 1980. The decapod crustaceans of Iowa. Proc. Iowa Acad. Sci. 87(3):81-95.
 74. Price, J. O. and J. F. Payne. 1978. Multiple summer molts in adult *Orconectes neglectus chaenodactylus* (Williams). Pp. 93-104, In: Fourth Int. Symp. on Freshwater crayfish, Pierre-J. Laurent (Ed.).
 75. Price, J. O. and J. F. Payne. 1984a. Size, age and population dynamics in an R-selected population of *Orconectes neglectus chaenodactylus*

- Williams (Decapoda, Cambaridae). *Crustaceana* 46(1):29-38.
76. Price, J. O. and J. F. Payne. 1984b. Postembryonic to adult growth and development in the crayfish *Orconectes neglectus chaenodactylus* (Decapods, Astacidae). *Crustaceana* 46(2):176-194.
77. Rabeni, C. F. 1985. Resource partitioning by stream-dwelling crayfish: the influence of body size. *American Midl. Nat.* 113(1):20-29.
78. Smith, E. W. 1953. The life history of the crawfish *Orconectes (Faxonella) clypeata* (Hay) (Decapoda, Astacidae). *Tulane studies in Zoology* 1(7):79-96.
79. Spurgeon, C. H. 1915. The eyes of *Cambarus setosus* and *Cambarus pellucidus*. *Biol. Bull.* 28:385-396.
80. Steele, M. 1902. The crayfish of Missouri. *Univ. Cincinnati Bull.* No. 10, Ser. 2. Vol. 2. 53 pp.
81. Strawn, K. 1954. The pushnet, a one-man net for collecting in attached vegetation. *Copeia* 1954(3):195-197.
82. Tack, P. I. 1941. The life history and ecology of the crayfish *Cambarus immunis* Hagen. *Amer. Midl. Nat.* 25:420-446.
83. Tarr, R. S. 1884. Habits of burrowing crayfishes in the United States. *Nature* 30:127-128.
84. Turner, C. L. 1926. The crayfishes of Ohio. *Ohio State Univ. Bull.* 30(11):145-195.
85. Volpe, E. P. and G. H. Penn. 1957. Dimorphism of chromatophore patterns in the dwarf crawfish. *Jour. Heredity* 48(3):90-96.
86. Wells, P. H. 1957. Additional studies on responses to light by cave crayfishes. *Anatomical Record*, 128(3):639.
87. Wells, P. H. and A. Witt, Jr. 1957. Recent collections of the albinistic cave crayfish *Cambarus hubrichti*. *Anatomical Record* 128(3):640. Abstract
88. Williams, A. B. 1952. Six new crayfishes of the genus *Orconectes* (Decapoda: Astacidae) from Arkansas, Missouri and Oklahoma. *Trans. Kansas Acad. Sci.* 55(2):330-351.
89. Williams, A. B. 1954. Speciation and distribution of the crayfishes of the Ozark Plateaus and Ouachita Provinces. *Univ. Kansas Sci. Bull.* 36(12):805-916.
90. Williams, A. B. and A. B. Leonard. 1952. The crayfishes of Kansas. *Univ. Kansas Sci. Bull.* 34(15):961-1012.
91. Williams, D. D., N. E. Williams, and B. N. Hynes. 1974. Observations on the life history and burrow construction of the crayfish *Cambarus fodiens* (Cottle) in a temporary stream in southern Ontario. *Canadian Jour. Zool.* 52(3):365-370.

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About the Author

William L. Pflieger — born in Columbus, Ohio, in 1932 — holds bachelor of science and master of science degrees from Ohio State University, and a doctorate from the University of Kansas.

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Pflieger has authored or coauthored numerous scientific papers. However, he is best known for his book, "The Fishes of Missouri,"

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He has been active in the Department's programs of protection of natural areas and rare and endangered species, and for many years was a member of the Missouri Natural Areas Committee.

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